MASSACHUSETTS INSTITUTE OF TECHNOLOGY

ECONOMIC FACTORS IN THE DEVELOPMENT OF A COASTAL ZONE

(A report prepared for the National Council on Marine Resources and Engineering Development)

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CHAPTER I

INTRODUCTION AND SUMMARY

Preamble

Currently before the Congress, there are a number of bills relating to the management of the coastal zone.* Recently proposed legislation meeting this description includes S2802, S3183, S3554, S3460, HR13247, and HR14845. These bills are in part a manifestation of the increasing dissatisfaction with the present means of allocating the coastal zone which operates essentially through the private market modified by local zoning and taxation policies. The majority of these bills provide for federal support for the establishment of state coastal zone authorities with broad ranged decision-making powers meeting federal standards. The bills differ primarily with respect to the federal agency to which the federal responsibility for the coastal zone will be assigned.

The purpose of this report is not to evaluate the respective merits of these bills or even of state coastal zone authorities per se, but to make three fundamentally important points relating to the future management of the coastal zone:

1. To develop the reasons for and the situations in which the private market will operate to allocate the coastal zone in a manner which is inconsistent with the values of the economy:

2. To develop the reasons for and the situations in which local control will operate to allocate the coastal zone in a manner inconsistent with the values of the economy.

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* For the purposes of this report, the term "coastal zone" refers to the land/sea interface including not only the narrow strip on either side of the shoreline, but also the hinterland and the offshore waters insofar as they affect each other. This definition is unsatisfactorily circular. In actual allocation problems, the definition of what is and what is not the coastal zone is contingent upon the problem at hand. If the problem is the provision of a recreational beach, then a rather narrow definition may be used. If the problem is the establishment of a containerport, the relevant hinterland may extend a thousand miles inland. While we find the more concrete definitions such as those used by the Committee on Multiple Uses of the Coastal Zone (the continental slope to a line joining the heads of estuaries) as useful guidelines, in an actual analysis they must necessarily be violated and reference made to the above general principle.

3. To argue that the fact that the present system can be expected to operate inefficiently in many coastal zone situations is a necessary but not sufficient condition for the establishment of more broad-based decision -making bodies. The proponents of such measures must not only argue that the present system is inefficient--an argument which this report attempts to make precise--but also that the decisions emanating from the more broad based body will be more consistent with the economy's desires than the present decisions, despite the fact that this body is necessarily further removed from the discipline of the market and from the localities which will be most affected by its decisions. The latter point is much more difficult to make then the former and the report suspends judgement on its general validity.

The report does tug down some principles by which such a body should operate. The report emphasizes that the responsibility of such a body is not to impute its own values (the values of the individuals on that body) to coastal zone decisions, but rather to attempt to discover what the values of the economy served are and then to be consistent with these values. The practical means for implementing this philosophy, cost benefit analysis, is briefly outlined and its application to coastal zone decisions explored in some detail.

This application and exploration takes place in part through the investigation of four specific examples of coastal zone problems:

(a) The provision of a recreation facility in Boston Harbor,
(b) The redevelopment of the coastal town of Hull, Massachusetts,
(c) The location of a nuclear power plant near Plymouth, Massachusetts,
(d) The establishment and location of a refinery complex in Maine and the associated oil distribution problem.

All these problems are taken from the coast of New England north of Cape Cod, an area we have termed the Northern New England Coastal Zone. This geographic specialization necessarily introduces a somewhat local flavor to parts of the study. However, the problems span a representative spectrum of coastal zone allocation decisions, and we believe that the principles developed through these investigations, if not specific results, are generalizable.

It should be emphasized that this report is aimed at coastal zone decision-makers, whether federal, state, or local, many of whom will have had little or no exposure to the principles of efficiency in resource allocation. Experienced practitioners of cost-benefit analysis will find little of methodological or theoretical interest herein.

They may note with interest:

a. Our emphasis on the explicit inclusion of uncertainty within the analysis using subjective probabilities;

b. Our uncompromising position with respect to secondary (our term is "parochial") benefits, especially from the point of view of the framer of federal policy toward the coastal zone.

The core of this report consists of Chapters 2,3, and 4. Chapter 2 outlines the economics of the coastal zone in the abstract, defines the concept of economic efficiency (makes precise the sense in which an investment or allocation can be said to be consistent with the values of the economy),points out the mechanisms by which the private market can fail to allocate the coastal zone efficiently and their relative importance, introduces the concept of parochial benefits,* and outlines how local control can sometimes operate to produce allocations which are more inefficient than the private market by overcounting of benefits to the locality which are balanced by disbenefits accruing outside the purview of the local authority. Finally, Chapter 2 considers problems introduced by the fact that the decision-making body can almost never predict the future upon which the desirability of their alternative investments depends with certainty, and introduces methods for incorporating this uncertainty within the cost-benefit analysis.

Chapter 3 illustrates the practical problems involved in the application of cost-benefit analysis to the coastal zone and some of its limitations through the investigation in some detail of a particular coastal zone problem, the development of a particular island in Boston Harbor for recreation. This alternative is analyzed from start to finish (with the help of some heroic assumptions about cost) both as a pedagogic device to illustrate cost-benefit analysis to those unfamiliar with it and as a means for developing the limitations of this method and showing how it must be combined with informed judgment in actual decision-making.

* In the literature, effects which we term "parochial benefits" are generally called "secondary benefits." However, our concept of parochial benefits is somewhat more limited than that ordinarily connoted by secondary benefits, hence the introduction of a new term. Parochial benefits refer to the benefits associated with the expenditures on the inputs to an investment and the respending of these expenditures.

Chapters 2 and 3 are based on a project by project type of analysis. Chapter 4 attempts to illustrate how such piecemeal analysis might be integrated into region-wide coastal zone development, pointing out that project by-project analysis can result in significantly inefficient suboptimization unless such integration is imposed. Chapter 4 also discusses alternative zoning and taxation plans for implementing regionwide development strategies.

A guiding philosophy of this effort has been that it is impossible to develop useful economics in a vacuum. Therefore, we have investigated a number of specific coastal zone problems in addition to our exemplary cost-benefit analysis. Three of these investigations are outlined in Appendices A,B, and C.

Appendix A is the study of recent decisions made by the coastal town of Hull, Massachusetts, which occupies a peninsula jutting into Boston Harbor and contains one of the best beaches on the northern New England coast. This study is not really a cost-benefit analysis. It is a case history of how coastal zone decisions are actually made rather than a normative example of how they should be made. This study illustrates how coastal zone decisions are viewed from the locality involved, indicating that the decisions which are made generally have nothing to do with economic efficiency, private market or otherwise, but are based almost entirely on the marginal effects of the proposed new development on the property taxes of the present residents. Hull is a unique piece of geography whose optimal development could materially affect the social welfare of the eastern Massachusetts region as a whole. This example indicates how decisions of this importance are being made and will continue to be made under the present system.

The second example problem given in the appendices addresses itself to the wisdom of the location of the Pilgrim Power Plant, a 655 megawatt nuclear installatinn presently under construction on lightly-developed shoreline south of Plymouth, Massachusetts. This effort attempts to assay the external costs or benefits associated with the plant's thermal discharge, and the effect of an industrial development on surrounding residential properties. This example was chosen because projections indicate that power generation will place rapidly-escalating demands on the shoreline in the not too distant future.

Our on-site investigation of the external effects associated with the plant immediately brought out the importance of parochial benefits to the local residents, pointing out once again that geographic localization of transfer payments is a major determinant of present coastal zone allocations. At the same time, our analysis of the effects on the marine ecology indicate that these latter effects are unlikely to be significant in this case. We caution against generalization of this result for it in part depends on some rather unique characteristics of Cape Cod Bay, but the analysis does serve to indicate that industrial uses will be part of an efficient allocation of the coastal zone even when nonmarket effects are included in the analysis.

The final example offered is a study of future oil processing and distribution systems for the northern New England coastal zone which is given in Appendix C. The question of the establishment and location of a refinery complex in northern New England is perhaps the single most important decision under active consideration with respect to the northern New England coastal zone. Appendix C points out that, if a refinery is to be built, its location should depend almost entirely on locational differentials in these nonmarket disbenefits. We believe that the refinery question deserves the most intensive sort of cost-benefit analysis in view of its critical effect on the overall development of the northern New England coast. However, no such an analysis is undertaken herein. Appendix C concludes with a comparison of alternative oil distribution systems fornorthern New England with and without a refinery.

While Appendices A,B, and C are, strictly speaking, logically independent of the core argument developed in Chapters 2,3, and 4, we regard them as integral parts of the report and as important as the core in developing an understanding of the practical allocation problems facing the coastal zone.

CONCLUSIONS AND RECOMMENDATIONS

After studying the economics of the coastal zone, this report concludes that conscientious, effective, long-range planning and control of the coastal zone at the state and federal levels will be required if serious misuse of the shoreline is to be avoided. The argument is as follows:

1. The basic premise of this report is that economics in a sense wide enough to cover all significantly important values, both market and nonmarket, can be usefully applied to coastal zone allocation, that is, to the problem of determining that mix of uses of a particular coastal zone which is most consistent with the values of the economy which uses that coastal zone.

2. We take the view point that the amount a person values a good, whether it be a market or nonmarket commodity, can--at least conceptually--be measured by the amount that he is willing to pay for that good under a postulated income distribution. Given this premise the report equates consistency with these values with an allocation of the coastal zone such that there is no change in allocation to which everybody would agree. Such an allocation is said to be economically efficient.

3. This report, after studying the private market as a means of coastal zone allocation, concludes that market mechanisms will result in an allocation of the coastal zone which is seriously inconsistent with these values. The reasons for this misallocation are all the standard market imperfections: transaction costs; undervaluing of collective goods, spillovers, and goods subject to decreasing costs; but they all seem to apply with special force to the coastal zone and they all systematically result in overallocation of the coastal zone to private uses and underallocation of the zone to public uses.

4. This report then examines the political organization which has evolved in part to correct the inefficiencies of the private market with respect to the coastal zone. For the most part, this consists of local zoning and taxation policies under the control of the shoreline communities. The report then points out that this is an inefficient means of allocating the shoreline for, even if each community operates optimally within its own confines, the total shoreline allocation will be suboptimal, due to lack of consideration of alternatives in which one community specializes in a certain shoreline function while another specializes in some other.

5. The report goes on to argue that not only will local planning fail to result in those corrections to the private market results which would make the coastal zone allocation efficient, but, even more importantly, they

will often result in allocations which are worse than the private market results. Whenever a local board is faced with a development proposal, its first thought is toward the secondary or parochial benefits of the project: the effect on local payrolls and retail earnings, broadening of the tax base, all those effects which from the point of view of the project and the economy are costs. This report argues that these parochial benefits are almost always not net benefits from the point of view of the entire economy, but rather transfer payments from the rest of the economy into the goegraphical locale of the project. To put another way, the same parochial benefits would accrue wherever the money which must be invested in the project was spent. Thus, from the point of view of the economy as a whole, these parochial benefits are usually a wash. Yet, with these wash benefits which are quite real to the local community, an aggressive developer can obtain zoning variances, tax abatements, etc. Given parochial benefits, the local community is in no position to bargain with the large-scale developer. If the development is large enough, an investor can whipsaw an entire state or region in this manner. The question of the location of a refinery in New England may be a case in point.

6. Given the inefficiency of the private market with respect to the coastal zone and the inefficiency of local control, the only feasible alternative appears to be control at the state level with some federal influence to prevent parochial benefits from being used against an entire state. We strongly support the Stratton Commission's recommendations concerning the establishment of state coastal zone management authorities.

7. However, the establishment of such bodies implies some rather heavy responsibilities. Once the discipline of the private market is abandoned, coastal zone analysis requires conscious economic analysis, for it is not enough to show that the present system is seriously suboptimal. One must also argue that the proposed changes in the allocation process will result in coastal zone usage which is more consistent with the economy's values than the old, a much harder job.

8. Insofar as coastal zone allocation can be regarded on a project-by-project basis, the methodology for implementing this conscious economics is cost-benefit analysis. Unfortunately, the present state of the art with respect to cost-benefit analysis and the coastal zone leaves much to be desired and, until a state coastal zone authority can reliably determine the use of the coastal zone most consistent with people's values, it cannot promise to

do much better than the private market or local political entities.

9. A case in point is the treatment of uncertainty. No one would claim that we can predict with certainty what the future effects of our present development in the coastal zone will be, or how we will value these effects, or what technological alternatives will be available to us in the future. However, uncertainty is rarely considered explicitly in present cost-benefit analysis. This is particularly crucial in the situations where the costs of being wrong vary greatly with the possible alternatives. An example is the development of marshland. If the marsh is developed and later undeveloped marshland turns out to be very valuable, then the costs of transferring back to marsh are quite high. If the marsh is not developed and turns out not to be very valuable, it can then be developed and the only loss is the differential in benefits in the interim. On the other hand, the economy cannot use uncertainty as an excuse for doing nothing. This report outlines how uncertainty can rationally be included in coastal zone, cost-benefit analysis.

10. Another problem with locational cost-benefit analysis is that, if performed too narrowly, seriously inefficient suboptimization can occur. The problem is to approach coastline allocation comprehensively while, at the same time, retaining analytical feasibility. Given the compromises that must necessarily occur, the results of cost-benefit analysis must be used with some judgment.

11. In summary, with respect to the coastal zone, we can conclude that:

a. The private market cannot be expected to operate efficiently, local control won't work due to overcounting of parochial benefits, so some form of state and federal action with respect to coastal zone development is necessary.
b. If this planning and control is to be beneficial, the state and federal agencies must have means for determining what is an efficient allocation of the shoreline.
c. Properly developed and applied cost-benefit analysis will furnish these means for many, but not all of the decisions which will have to be made. This report is a preliminary effort at this development and application.

CHAPTER II

THE ECONOMICS OF THE DEVELOPMENT OF A COASTAL ZONE

The Basic Problem

The problem is how to allocate an essentially fixed supply of coastal zone resources among the growing public and private demands for coastal areas. The historical answer has been to allow supply and demand to determine the usage of coastal areas through the price mechanism--the use which would pay the most for the property obtained it. Zoning provisions, public ownership, and tax laws have all had an impact on the market results, but the current allocation is essentially the result of private market operations. Increasingly, these results are being called into question. This dissatisfaction requires some explanation, for it is not difficult to demonstrate that the allocation of resources resulting from competitive market operations can have some rather attractive properties.

Before we can make any substantive statements about how society should allocate the coastal zone, we will have to establish a frame of reference, a basic set of assumptions about society's goals, about what is good and what is bad, with which assumptions we desire our coastal zone decisions to be consistent. It is the purpose of this section to exhibit the set of assumptions about social values with which we will operate in this report and to contrast this set of assumptions with some of the other possible viewpoints that one might take.

Some Basic Considerations Regarding Social Choice and Public Investment

After the inevitability of death, perhaps the most pervasive, the most basic fact of life for both an individual and society is that neither can have as much of everything as he or it desires. At any point in time the amount of all types of resources--land, minerals, water, air, machines etc.--is fixed. This basic limitation implies that a society cannot have all it wants of everything. It must forego some goods in order to obtain others.

The term good, in this context is to be interpreted in its original sense to mean anything desirable whether it be a material good (a physical commodity), a psychological good, an esthetic good, or whatever. Thus, air quality or esthetic architecture is a good in this context as long as more is preferred to less everything else being equal. (Note that without loss in generality we can define all non-material goods in question in a positive sense. That is, we will talk in terms of air pollution abatement or water quality rather than level of pollution).

However, there is one important difference between the typical material good and the typical non-material good which we must keep in mind from the onset. Most material goods have the characteristic that the use or consumption of a unit of the good by one person effectively prevents someonw else from consuming the same unit of that good. On the other hand, many non-material goods such as clear air or beautiful scenery can be consumed communally. One person's enjoyment of the good does not prevent, or often even diminish, the ability of the good to be enjoyed by another. We shall call goods which fall into the first category <u>private goods</u> those which fall into the second, <u>collective goods</u>, and will have cause to refer back to this distinction in the future.

For now the basic point remains, in terms of the underlying limitations on our set of resources, it is clear that all types of goods, both private and collective, compete with themselves and with each other for an economy's resources in the sense that only certain combinations of all goods are attainable given the fixed set of resources. This set of attainable combinations of goods is generally represented by the production possibilities surface which is defined by

$x_j(x_1, x_2, \ldots, x_{j-1}, x_{j+1}, \ldots x_N) =$ maximum amount of jth good attainable given that all the other goods are fixed at levels $x_1, x_2, \ldots, x_{j-1}, x_{j+1}, \ldots, x_N$.

It should be clear that this definition is symmetric in the x_j's and generally the production possibilities surface is represented implicitly in the following symmetric form.

$$T(x_1, x_2 \ldots, x_N) = 0$$

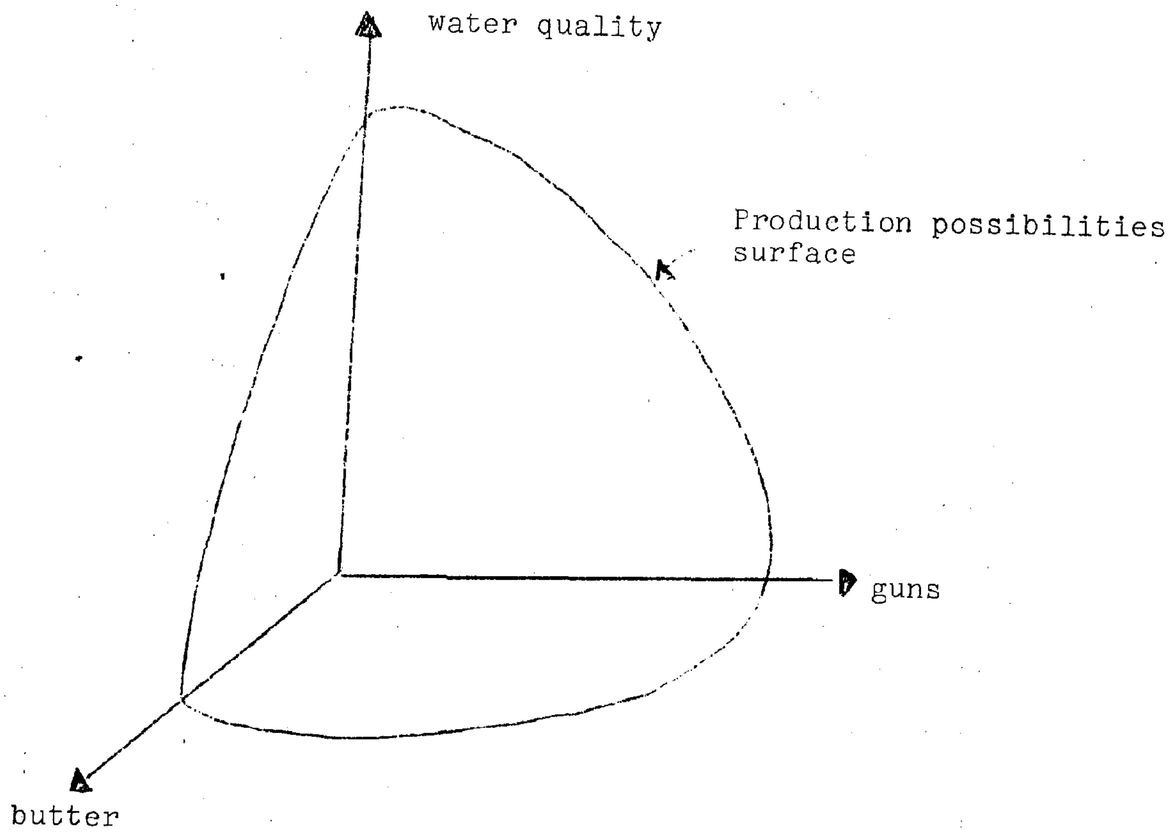
The production possibilities surface divides the space of all combinations of goods into three mutually exclusive subspaces.

$$T(x_1, x_2, \ldots, x_N) < 0$$

$$T(x_1, x_2, \ldots, x_N) = 0$$

$$T(x_1, x_2, \ldots, x_N) > 0$$

Figure 2.1 illustrates a possible, three dimensional production possibilities surface.



Points inside the surface represent wastefull combinations of butter, guns, and water quality.

Points on the surface are wastefree

Points outside the surface are infeasible

FIGURE 2.1 A HYPOTHETICAL PRODUCTION POSSIBILITIES SURFACE FOR A THREE GOODS ECONOMY

In the first case, the combination of goods is such that the society could have more of at least one good without giving up any of another good, or equivalently the society could have more of every good.* We shall call such a combination of goods wasteful. In the second case, the combination of goods is on the production possibilities surface and the society cannot have more of any good without giving up a positive amount of some other good (s). In this case, the economy will be said to be wastefree. In the final case, the combination of goods is not attainable by any arrangement of the resources of the society and this combination is said to be infeasible.

This very basic breakdown points to two interrelated but distinguishable subproblems within the general problem of determining how a society's resources should be allocated:

A. Problems involved with moving from a wasteful to a wastefree allocation which offers more of all goods then the wastefull.

B. Problems involved in choosing from among the wastefree allocations, from among the points on the production possibilities surface.

Problem A is clearly a technical problem because everybody will agree that the move is beneficial. This technical problem involves identifying a change in allocation that is better or at least as good in every dimension as the present allocation. At the project level, this is the domain of cost-effectiveness where one specifies the levels of all dimensions except one and searches for that alternative which maximizes the remaining dimension,generally termed effectiveness. Thus, no conceptual problems attend cost-effectiveness type problems. However, such analysis, should not be disparaged: there are many more wasteful proposals around than wastefree and the determination of the wastefree ones (more precisely, the ruling out of the wasteful ones) is almost always useful and rarely trivial.

However, the remainder of this section and the bulk of this report will be addressed to problem B and means of choosing one among the set of wastefree allocations which somehow is to be more preferred by the society

* As long as more of one good implies less of another good along the production possibilities surface, if one can increase one good while holding all others constant, one can increase more than one good without giving up any of the other goods.

than others.

Essentially, four different methods for making this difficult choice have been suggested in the past. We might characterize them as follows:

1) The dictator,
2) Intrinsic suitability,
3) Representative political consensus,
4) Willingness-to-pay.

The basic problem here is that in order to choose between the points on the production possibilities surface, one must impute a set of values to this surface. One must, for example, decide whether a society values 100,000 tons of steel more than a 10% decrease in air pollution, one car more than ten TV sets, etc., for all combinations of such commodities on the production possibilities surface. This would be a difficult problem for an individual, let alone a society whose purpose is to somehow reconcile the differing value systems of each individual.

1) The first of our methods, which we have called the dictator, in which an individual or a small cohesive group unabashedly equates its own values with those of the society is historically one of the most popular methods and counts among its attempts at allocation some of the developments of which man is most proud. It has had its failures and does have its disadvantages. The most basic one is that it begs, albeit in a rather effective manner, the basic problem of reconciling individual value systems. If a society accepts one of a number of ethical precepts about the value of the individual, this at-times-attractive possibility is no longer open to it. Therefore, since we are attempting to shed light on the coastal zone allocation problem in a country which has made an at least theoretical commitment to the individual, we will consider it no longer. Perhaps the most important present-day proponents of this system in the USA are certain of the more architectural schools of thought in urban planning.

2) An allocation scheme for land which has achieved some prominence in the last few years is based on the idea that, on the basis of natural geological and ecological characteristics, one can identify certain areas as intrinsically suitable for certain purposes and other areas as intrinsically unsuitable for other purposes. Having made this identification, one implements zoning procedures consistent with it. This viewpoint, which

underlies the arguments of many conservationist groups, has been most fully developed by McHarg, reference(1).

This philosophy raises questions of how one determines intrinsic suitability and, more basically, if one bases development decisions strictly on natural characteristics, one may find, for example, that all of Oregon is intrinsically suitable for recreation but none of Nebraska. However, it is not clear that zoning provisions implementing this finding would lead us to the allocation which would be most consistent with society's values, however defined. Even more importantly, this approach begs the hard questions which are precisely the issues on which the decisionmaker needs the most help. For example, one may determine that Machias Bay in Maine is intrinsically suitable for preservation and wilderness recreation (it is an unusually beautiful bay which is probably unique on the East Coast with respect to lack of previous development) and also that Machias Bay is intrinsically well suited to oil transhipment (it is unique on the East Coast in being able to handle tankers of greater than 80 foot draft within 1/4 mile of shore in sheltered water with direct access to the sea).

In actual practice, this scheme, at least as developed by McHarg, is applied very flexibly, leaving a wide range of alternatives open. In short, pushing this idea very hard leads to some rather strange allocations; insofar as the idea is not pushed hard, it begs the basic question and becomes a useful adjunct to allocation rather than a means of determining this allocation.

3) Some form of representative political concensus, based directly or indirectly on the ballot, is practiced presently in a large part of the world. Such a process would be strengthened and formalized under present legislative proposals with respect to the coastal zone.

The ballot in all its forms has its share of problems both practical (keeping representatives' values consistent with constituents', providing a spectrum of alternatives) and theoretical (tyranny of the majority, indivisibility of the vote). Attempts to be precise about the manner in which a representative process is or can be made to be consistent with the values of the society represented have either been unpersuasive or productive of only negative results (e.g. the intransitivity of democratic choice).(2) This report will attempt no such analysis of the political structure of either the representative process in general or the rather unique political structure of the Northern New England Coastal Zone in particular; but rather take as obvious:

a) The political structure we are dealing with does have the ability to take substantial discretionary action--to commit resources, regulate markets, and transfer income.

b) This political structure wishes to make those decisions which are somehow consistent with the values of the society it represents.

c) And that this political structure needs help in determining which of its alternatives merit implementation under the above criteria.

In short, this report is going to accept the representative consensus view of life in some ill-defined sense and to be concerned with making this definition more precise only in so far as resource allocation is concerned.

4) This brings us to the fourth valuation scheme which we will call 'willingness-to-pay'. Under this set up, each individual is regarded as the sole judge of his own welfare. Furthermore, each individual is assigned control (private property rights) to a certain amount of resources (land, capital and labor) and he is free to exchange these resources for any of the goods produced by the society according to any mutually agreeable bargain with the controllers of these goods. Generally, this exchange is facilitated by a surrogate good called money which has the advantages of being universally accepted, divisable, easily transferable, etc. in which case the individual's control over his set of resources translates itself into income.

Given this setup one can rank a person's preferences according to his willingness to pay. Thus, if a person is willing to pay $1.00 of his income for a hamburger and 50 cents for an object d'art, then by this scheme we presume he values the hamburger more than the piece of art, and that if he obtains the hamburger he is better off than if he obtains the work of art. Thus, we are assuming that all the values a man has for a good whether it be a material good, an esthetic good, or a psychological good can be quantified by finding out how much of other goods he would be willing to forego to obtain the good in question. Note that this valuation scheme applies to collective goods as well as private goods. Thus, if someone claims he values a certain decrease in air pollution more than a TV, yet a group is formed which with the aid of $100 from him could achieve the increased air quality and the man spends his $100 on the TV, we regard his claim as, at best, meaningless.

Given that one accepts this valuation scheme, the problem is to find that public policy which tends toward that configuration of the coastal zone which is in some sense consistent with the values so measured. We shall put off for just a moment discussion of what we mean by "consistent with willingness-to-pay" to discuss a very important limitation on this valuation scheme.

In order to use this scheme, one must accept or assume a distribution of income, for willingness-to-pay clearly depends on income. Every change in the distribution of income will, in general, alter the amounts that people are willing to pay for various goods and, however we define consistency, if we are to be consistent with the new set of values, the allocation must change accordingly. Thus, if one does not regard the present distribution of income as desirable, one cannot be expected to be happy with the allocation consistent with the present "willingness-to-pay".

The acceptance of an income distribution then is a critical enabling hypothesis underlying all the analysis that follows. Therefore, it bears some investion. First of all, it is patently clear that society is not completely satisfied with the present distribution of income. The existence of charitable organizations, a progressive income tax, Social Security and welfare, public housing, and myriad other existing and proposed programs are manifestations of the society's dissatisfaction with the present income distribution. On the other hand, if one doesn't accept the present income distribution, then one is faced with the problem of choosing society's desired income distribution on the basis of very little information, if indeed the concept has existential meaning.

Generally, our approach will be to work with the present distribution of income, not withstanding the above mentioned clear indications that society does not regard this distribution with complete favor, on the following grounds:

1) Despite the above, society does not appear to be prepared to opt for a radically different distribution of income.

2) If a different distribution of income is desired, it is generally more efficient to effect the desired income transfers through lump sum payments or, failing that, through differential taxation of income, then through income transfers via public investment or direct interference with markets.

3) The most important reason for accepting the present distribution of income is that this hypothesis, despite its untenability in the strict sense, will prove useful. That is, as so often happens in science, we shall see that provisionally accepting a hypothesis known not to be completely true, will allow us to proceed with analysis which will reveal important facets of a problem which facets would be difficult to exhibit without this assumption.*

4) Finally, we will not push this hypothesis too hard. In cases which the acceptance of the present distribution of income is clearly inappropriate, such as in the provision of an intown beach aimed at ghetto poor, we will revert to analysing a range of possible sets of willingnesses-to-pay resulting from a range of possible income distributions, obtaining for each such set of values, the system which is consistent with that set of values. The resulting analysis will not uniquely specify which is the indicated alternative, but rather will serve to rule out all those alternatives which are not consistent with any reasonable set of values. The community or its representatives will somehow have to decide among the remaining alternatives. As we shall attempt to demonstrate in Chapter III, this ruling out process can be of a much more value to the relevant decisionmakers in difficult situations than the specification of a single "optimal" alternative in simpler situations.

We shall have cause to return to the problem of the specification of the income distribution in the sequel, for now let us at least provisionally accept the present distribution of income and examine in what sense we can identify a particular configuration of the

* The alternative is to revert to a vague discussion of social welfare, which at best is non-productive and at worst leads to such antinomious concepts as "the greatest good for the greatest number", or "maximum regional income with minimum pollution."

economy--a particular set of goods produced--as consistent with the resulting willingness-to-pay.

Pareto-Efficiency

Consider a point on the production possibilities surface, some wastefree combination of goods. Now consider a proposed change in the combination of goods produced. Some people will be willing to pay to see this change occur. Some will be willing to pay to avoid the change. If the people who desire the change are willing to pay more than people who oppose it, say a total of A versus a total of B with $A > B$ then, if we make the change and at the same time take B from the proponents of the move and pay it to the opponents, then, after making the change, the opponents will regard themselves as well off as before --they have suffered the disbenefits of the change but have been compensated by the amount they value these disbenefits--while the proponents will consider themselves better off then before for they regarded the change as worth A and received it for only B. Or we can make the change and take some amount of income between A and B from the proponents and give it to the opponents in which everybody will regard themselves as better off than before in terms of their own willingness-to-pay. Everybody would be willing to pay a positive amount for the change and compensation. Thus, accepting individual willingnesses-to-pay as a valuation scheme, such a change is an improvement in an unambiguous manner Everybody finds themselves at least as well off as before (by their own values). If everybody's lot could be improved, in this manner, the orginal position could not have been consistent with maximum social welfare defined in terms of willingness-to-pay.

With this argument as a hint, let us postulate the following criterion for the narrowing down of the set of points on the production possibilities surface which we can regard as consistent with the postulated income distribution and the resulting individual willingness-to-pay.

A COMBINATION OF GOODS CANNOT BE CONSISTENT WITH WILLINGNESS-TO-PAY UNLESS IT IS IMPOSSIBLE TO MAKE A CHANGE IN THE COMBINATION OF GOODS PRODUCED, WHICH MAKES AT LEAST ONE PERSON BETTER OFF AND NONE WORSE OFF.

While this criteria appears to be pleasantly noncontroversial in that it seems to avoid comparing one person's welfare with anothers it also appears woefully incomplete. Most of the interesting real world choices leave some people better off and some worse off and the criterion does not seem to speak to these choices. However, appearances are deceiving, a basic result of micro-economic theory is that once we have accepted an income distribution and the possibility of compensation, the above criteria is quite specific and in fact there is an operationally unique configuration of the economy which is consistent with the above criterion and the postulated income distribution. (3). Our criterion appears to avoid interpersonal comparisons but, in fact, such comparisons are implicit in the acceptance of the income distribution.*

Social judgments based on the above criterion are said to be Paretian and the configuration of the economy such that no one can be made better off with out someone being made worse off is said to be the Pareto-efficient (or sometimes, just plain efficient) configuration associated with the postulated income distribution.** Thus, if we are going to follow the above criterion, we must specify an income distribution and then attempt to develop public policy which encourages the Pareto-efficient configuration of the Coastal Zone associated with the specified income distribution.

Pareto-Efficiency and the Private Market

Not only is there a unique configuration of the economy which is consistent with willingness-to-pay in the manner outlined, but further, in so far as there are properly functioning markets for all goods valued by the society, then it can be shown that the price mechanism operating through these markets will tend toward the Pareto-efficient configuration of the economy consistent with the present income distribution.

* As we shall see, in practical applications this specificity is more than a little misleading, as it turns upon the possibility of compensation for all persons adversely affected by a particular change. In the real world this compensation may not be feasible for a variety of political and economic reasons. However, this "theoretical" specificity does serve as a firm foundation upon which we can make judgments about public policy concerning the coastal zone if we accept willingness-to-pay as a yardstick.

** A completely equivalent and slightly more concise way of wording this is to say "it is impossible to make everybody better off", for if one can make one person better off hurting nobody, one can take some of the increase of goods from the person made better off and distribute them among all others.

(3) In essense, this is a result of the fact that, in a price system, he who is willing to pay the most for a good obtains it.

Thus, given this report's provisional acceptance of willingness-to-pay and this characteristic of the market system, if there were properly functioning markets for all coastal zone goods, we could end the report here. In actuality, this is only the beginning, for throughout the economy and in particular in the coastal zone, there are many goods for which properly functioning markets do not exist. In fact, there are a number of goods of increasing social importance for which no recognizable market exists. Therefore, our task is just begun, and we turn to a more detailed investigation of those areas in which the private market system will not be consistent with willingness-to-pay.

Private Market Failures

The requirements for a private market economy operating through the price system to tend toward Pareto efficiency include:

A) Private access to all goods.

B) The amount of other goods foregone due to the production of a unit of a particular good must not decrease with the increased level of output of the good in question.

C) There exist markets for all possible goods including side effects. It is not possible for a producer and a consumer to, as a result of their production and consumption, decrease the goods enjoyed by a third party without the third party obtaining compensation.

D) The provision of the information required to effect the agreements and bargains through which the private market operates does not itself consume resources.

Unfortunately, these conditions are often violated throughout the economy and particularly along the coastal zone where development is intense and the social and ecological interrelationships of various activities are critically important and where, for at least the offshore portion of the coastal zone, private property rights are difficult to establish. In the following paragraphs we review some of the situations in which we can expect the private market to operate inefficiently in the coastal zone.

In so doing, we shall find it useful to adopt the following definition. The <u>cost</u> of a unit of particular good is the maximum amount the people in that society would be willing to pay for the goods foregone by the society in order to obtain that unit of the good in question. In terms of this definition conditions B and C can be restated: (B) The cost of a unit of a good must not decrease with increased level of production of that good. (C) The consumer(s) of a particular unit of a good should bear the full cost of the production of that unit.

Notice that this is a technical definition of the word cost which need not correspond to the common usage meaning, roughly, the monetary outlay required to obtain a good. It just so happens that, under willingness-to-pay, in a perfectly functioning price system, the monetary outlay required to obtain a good and the value of the goods foregone due to the consumption of this good are the same. Thus, in so far as our economy is not a perfectly functioning competitive economy, in so far as the above conditions are not met, a situation known as private market failure, we will have to be careful to distinguish between the two different usages of the word cost. In the sequel, when the meaning is not made clear by the context, we shall use the term social cost when we are referring to the first definition and private costs when we are referring to the second meaning.

We shall now consider each of the above conditions in turn.

Collective Goods

The price mechanism will fail to operate in a manner which is consistent with willingness-to-pay when dealing with collective goods. Collective goods differ from private goods in that individuals do not obtain exclusive possession of the goods they purchase; they are not able to exclude others from the use of these goods. The prototypical example is national defense. If one cannot exclude or be excluded from a particular good, then it is rational for each citizen operating individually to refuse to buy a good he desires, forcing others to purchase the good which he then enjoys without cost to himself. Of course, others reason similarly and the good, for which the group as a whole may be willing to pay a great deal, will not be provided. Thus, collective action either through regulation or public investment will be required if the Pareto-efficient allocation is to be obtained in this situation.

In addition to goods which are pure collective goods, i.e. exclusion is impossible, everyone must consume the same quantity, there is a more general and much more numerous class of goods for which exclusion is technically possible but for which the amount of resources (the cost) of obtaining this exclusion is quite high, or society has not found a politically feasible means of implementing this exclusion. Examples include radio and television entertainment, highways, and access roads.

The private market can also fail on the input or resource side due to difficulties in exclusion. One of the most glaring examples of this kind of failure relates directly to the coastal zone. Society has barely begun to evolve a workable form of property rights to certain offshore resources such as the seabed. It has yet to begin to establish any workable form of control of the resources in the water column. This leads to the so-called common pool problem with respect to, for example, fisheries. At present, private property rights can not be established on fish until the fish are caught.

In this situation, there is no incentive to husband the crop. Fishermen operating individually will mine the resources at a higher rate than would be rational if the fish were privately controlled, for each will reason that if he doesn't catch the fish someone else will. In extreme cases, this leads to rapid depletion of a fish stock and the establishment of piecemeal, generally, ineffective, and almost always wasteful attempts at regulating the fishery in question.(4)

In general, then the unaided price mechanism cannot be expected to operate toward a Pareto-efficient configuration when prices in cases where private property rights (exclusion) cannot be established efficiently. On the goods (output) side this leads to underprovision of collective goods by the private market, and on the resource (input) side it leads to overexploitation of those resources for which private property rights cannot or have not been established.

Goods Subject to Decreasing Costs

There is a technical situation which presents a very difficult problem for the private market. When it works, the price mechanism owes its success at establishing Pareto-efficiency in part to the fact that each person is forced to give up the social costs of his consumption of a unit of a good in order to obtain the use of that unit. This assures that all goods for which the value of the use is greater to somebody than the value of the resources used in the provision of that unit of a good elsewhere is supplied. A market system also requires that everybody be charged the same price for the same good. (Obviously, all buyers are going to go to the low price source of the good.) Now consider these two facts and the following sort of situation. Let us suppose we have a good in which, given the present set of investments, the costs of supplying an extra unit of that good to a consumer is quite low. These additional costs are called the marginal costs of the unit of the good. It will pay the producer to supply this unit at any price above its marginal cost and in a competitive market the price will be driven down to the marginal cost and all units of the good (not just the additional unit) will be sold at this price. If N units of the good are sold, the revenue to the producer will be $M(N) \cdot N$ where $M(N)$ is the marginal cost. Unless $M(N) \cdot N$ is greater than $T(N)$ the total cost to the producer of supplying all the N units of the good including investment costs, then the supplier will not make the investment required to supply this good. None of the good will be produced. This can happen despite the fact that the total amount that society is willing to pay for this good is greater than the social costs of producing it, some of the buyers may be willing to pay much more than marginal costs for a particular unit of the good.

This dilemma can also be expressed in terms of average costs. The average cost of producing N units is defined to be $T(N)/N$. Thus, the condition that $M(N) \times N$ be greater than or equal to the total costs will not be met if the marginal costs are less than average costs at the level of production called for by the market. It is easy to show that, average costs will be less than marginal costs if and only if average costs decrease with increased output.

In short, Pareto-efficiency requires that all consumers be charged the marginal cost of producing a unit of the good in question. However, if a private investor charges marginal costs in a situation where marginal costs are less than average costs (average costs are decreasing) he cannot recover his investment and the project loses money. If average costs are charged, the project breaks even but the project is underutilized and resources are inefficiently distributed.

The textbook example of this sort of market failure also occurs in the coastal zone. Consider a lighthouse. Once it is build and its light is flashing, additional ships may use the service without adding to the cost of operations--the marginal cost of an additional ship is sensibly zero.

Lighthouse services should be supplied if, and only if, the total amount all the users would be willing to pay for the lighthouse (total savings due to smaller number of shipwreaks and collisions, less delays, etc) is greater than the social cost of constructing and operating the lighthouse. At the same time, the charge to users should be zero since the cost of the additional use is zero. If not, a potential user whose savings resulting from the use of the service is just barely positive would be dissuaded from using the service. Then we would be in a situation where one person (this user) could be made better off (by allowing him to use the service free) while making no one worse off. But no private investor could be expected to devote resources to the construction of the lighthouse if the price of his product must be zero. Hence, collective action is indicated.

The pervasiveness of goods subject to decreasing average costs is often underemphasized. They include not only almost all goods requiring large indivisible investments up to capacity, almost all transportation and distribution services up to congestion, and almost all communication and information transfer services. With respect to the coastal zone, obvious examples are navigation and recreation facilities up to capacity, scheduled shipping services and the provision of terminals for marine transportation, power generation,and undersea oil production. In short, a substantial proportion of the uses to which the coastal zone may be put are subject to decreasing costs which goods will be provided inefficiently (through monopolies or cartels), if at all, by an unregulated free market.

Spillover Costs and Benefits

Perhaps the single most important reason for the rising dissatisfaction with the private market as a means of allocating the coastal zone has to do with spillover effects. Spillovers refer to the effects of one person's consumption of a particular good on people other than those doing the actual consumption. The private market conceives of a series of buyer-seller transactions in which no one other than the buyer and the seller are affected by the agreement that this pair reaches. In actual fact, there are few important economic transactions which can be made today which do not affect a large number of people, albeit often in a diffuse manner. Elbow room is scarce both because of the increase in population in general and because our elbows, magnified and multiplied by modern technology, are bigger and sharper than ever. Before 1900 a man chose to buy and ride a horse and the only third party effects were an occasional dirty shoe.

Now a man in a car can add to the discomfort of an entire town. And things promise to become increasingly difficult. The number of possible social contacts and hence occasions for third party conflicts grows combinatorially with population. As for technology, an agreement between an airline and a passenger may soon have the ability to inflict discomfort on a person on the seasurface tens of miles away from the plane.

Some of the most important of these uncompensated third party effects have to do with our use of the environment as a sink for the material and energy flows generated by an industrial society. Ayers and Kneese have pointed out that even our use of the term consumption is misleading.(5) In actual fact, relativistic considerations aside, matter is conserved and not consumed. Material goods are at most altered by our "consumption" of them. Their material substance remains and must either be reused or discharged to the environment. The same thing is true of energy. Generally speaking, the discharge of the residuals to the environment takes place without any compensation to those who are adversely affected by this discharge. This would cause no great problem if the adverse effects were small, as perhaps they were in the past. However, cases are rapidly multiplying which indicate that in many situations our discharges are exceeding the assimilitive capabilities of the environment. As this happens, the adverse effects become very large very fast, especially in view of the fact that many ecological systems exhibit decreasing ability to handle effluents when overloaded. This can lead to an explosively unstable situation.

Given the magnitude and growth of our material flows and the fact that we are beginning to overload natural systems in many situations, it is clear that we can no longer regard these third party effects as "somewhat freakish anomalies" in an otherwise smoothly functioning economic system (6).

We will illustrate by several examples taken from reference (7), how these third party effects can prevent the market mechanism from functioning in such a manner as to lead the society to a Pareto-efficient economic configuration, that is, to get us into a situation where everybody would be made better off in terms of willingness-to-pay by proper interference with the market mechanism.

Consider the problem of the heating of large buildings. This function presently contributes 30% of the sulphur discharged into Metropolitan Boston airshed. (8) Now, according to the oil used and the amount of treatment employed, more or less sulphur will be discharged into the atmosphere as a by-product of space heating. The building owner is interested in profits and he will choose that oil and that level of treatment which performs the required heating at least private cost to him. In the absence of public action, the building owner can be thought of as envisioning his use of the atmosphere as a free resource.

Although the use of the atmosphere might be viewed as a free resource by the heater it is certainly not without cost to those residing in the adjoining areas. Not only does sulphur in its various forms contribute to the deterioration of building exteriors and machinery corrosion, it almost certainly has an effect, not yet completely documented, on public health, and may simply be an esthetic bad, in the sense that people would pay to avoid this bad, even if it had no physical effect on men or materials. To the building owner the discharge is free; to society it has a cost. Private cost is not equal to social cost. Yet, we have seen that a necessary condition for Pareto-efficiency is that each member of socity bears the marginal social cost of his actions. In this case, the building owner does not bear the social cost of his actions and hence will discharge more sulphur than he would if he was forced to bear them. The resulting configuration may not be Pareto-efficient. In this case, it may be possible to make at least one person better off and no one worse off through public action. This would be the case if the amounts that those adversely effected by the sulphur in the air were willing to pay to see a certain decrease, exceeded the private cost to the heater of effecting this decrease, for these people would be indifferent between paying this amount and suffering the present level, but the building owner would consider himself better off after accepting the payment and paying the cost of the decrease. The unaided private market will never consider this possibility, for there exists no market through which those adversely affected by sulphur in the air can demonstrate their willingness to pay for less sulphur. In part, the reason for the failure of such a market to evolve is a product of the fact that air quality is a collective good.

The collective aspect of third party effects can be seen more clearly in the next example; the automobile. Assume that an effective automobile smog control device exists. It is obvious that, if consumers demand and are willing to pay for such devices, the automobile industry would develop and sell these devices with no public prodding. The question is, would the public, acting individually, demand the number of smog control devices consistent with its own willingness to pay for air quality? The answer is no. For a person who was considering whether or not to order a smog control device on his car would reason, quite rationally, as follows. If I purchase the device andeveryone else does likewise, then we will have less smog in the city. On the other hand, my individual car can add only a negligible amount to the smog problem so that if everyone else purchases and I do not, I will enjoy sensibly the same air quality and have saved the price of the device. Thus, if everyone else purchases a device, I will be better off if I do not get one. On the otherhand, if no one else other than myself, purchases a device there will be a bad smog problem. However, If I purchase a device the problem will not be noticeably different, since my individual car contributes a very small part of the overall smog and I will be out the money I paid for the device. Thus, if no one else purchases, I shouldn't either. Obviously, the analysis is the same if some people purchase and some do not. In each case, the amount the individual would be willing to pay for the difference in the smog due to the purchase obtains from <u>his own</u> smog control device is less than the price of the device.

Since all potential car buyers will reason in a similar rational manner, the result is that there will be zero demand for smog control devices. The automobile manufacturers will have no motivation to develop and market such a device. This conclusion holds even if--and it is an if--collectively the public would be willing to pay the cost of smog control devices for all cars in order to obtain the resulting air quality. The point is that each prospective buyer of a device suffers only a small part of the pollution cost of his decision not to buy the device. If he is one man in a million man city, he suffers, very roughly speaking, one-one millionth of the pollution cost. Once again private costs do not equal social costs. A third party (the rest of the community) is affected by the decision to buy or not the device but is not party to the exchange.* (Please see next page)

For a third example, consider the problem of pollution of an estuary by sewage emanating from a number of municipalities located on the estuary. For the purposes of discussion, imagine that the entire problem of pollution is caused by organic material so that treatment which removes the organic material, which otherwise is broken down by biological processes which consume the estuary's oxygen, could solve the problem. (This is not the case. Inorganic fertilizers often are a bigger problem then oversaturation of the oxygen supply.) The now familiar dilemma would act to frustrate a market solution. Each municipality or sewage district would reap but little of its own efforts at treating the sewage, but it would bear the full costs of the treatment. The third parties in the rest of the estuary would not have to bear the costs of the benefits they would perceive from the individual town's investment in sewage treatment. Each individual town would come to the rational decision to not pay the cost of treating its sewage even though all might be better off if all the towns installed such treatment.

In short, wherever there is a spillover or third party effect for which no market exists, the price mechanism may result in an economic configuration which is inconsistent with the society's willingness to pay and public action

* This example also points out the futility of appeals to conscience and social responsibility in situations where social costs are not equal to private costs. The more likely the appeal is to work, the less motivation there is for an individual to be persuaded by the appeal. If, due to an appeal a large portion of the population bought smog control devices, the remaining individuals would have no need to be concerned about smog, let alone invest in further reduction of pollution. The futility of such voluntary approaches is well recognized in most of the situations with which we will be involved in this report. The only area where such appeals are still given any credance involves, unfortunately, the single most important example of the divergence of private and social costs, population control, a divergence which is increased not decreased by present public policies. This problem is well treated by Hardin(9). In this report, population is regarded as an exogenous parameter (not influenced by the decisions being analyzed). Unless this very important assumption is made, the objective of being consistent with individual willingness-to-pay has little operational meaning for, if population is a variable, willingness-to-pay can point to policies which lead to large populations with individually small willingness-to-pay.

through regulation or investment may be warrented.

It is important to note that spillover effects can be positive as well as negative. Some goods have positive effects to third parties in addiiion to the private benefits they produce. Education may be an example. It can be and is old privately. It produces many private benefits, but it also produces a set of social benefits in terms of economic growth, political participation, and perhaps social stability. Often, these types of goods are called "merit wants." Since each individual will only consider private benefits when purchasing these types of goods, each individual will purchase too little of these goods when both private and public benefits are considered. Thus, society often provides such goods free or subsidizes them so that individuals will consume more than they would if the private market were allowed to function unaided. Recreation and housing may both fall into the category of "merit wants." With merit wants or goods, your consumption of the good has a positive impact on my welfare level.

Contracting Costs

A fourth type of market failure which pervades the whole economy and which may have special significance for locational decisions involves the problem of contracting costs. Strictly speaking, a private market can achieve Pareto-efficiency only if the social costs of achieving and insuring the voluntary agreements through which the market operates, and of providing the information upon which these agreements should be based, is zero. In actual fact, the costs of achieving such agreements and such information can be quite high and sometimes prohibitive. A significant portion of our national resources is devoted to marketing and procurement, to sales staffs, police, brokers, lawyers, and advertising; and still the quality of the information and the variety of contracts available is often far from satisfactory. The cost of achieving a sale for some retail items can run many times the cost of material, fabrication, and transportation. A primary motive for vertical integration may be reduction in the contracting costs associated with interfirm transfers.

In situations where contracting costs are large, reliance on governmental allocation mechanisms may be more efficient than the use of the market for government need not incur the costs of securing the consent of all those who would have to be a party to a voluntary agreement. Of course, giving up the test of consent places a heavy burden on government to insure that the proposed allocation would obtain this consent. This is precisely the reason for cost-benefit analysis which is nothing more than a systematic means of estimating whether this consent would be forthcoming.

Contracting costs can enter into locational decisions in a manner which may have special significance for locational decisions in heavily populated areas such as the coastal zone.

Consider the case of regional development around a large coastal city. For some reason ranging from a unique geographic advantage to "this was where the wagon broke down" development started at this point in space. Once it was started it was socially and economically advantageous for others to locate near the development to attain the social advantages of contact and the economic advantages ranging from decrease in transportation costs to the benefits accruing from the specialization a larger group allows. In time, more firms and more individuals maximizing their own ends, while considering the locational decisions of others as fixed, find that in this constrained situation the best they can do is to locate in and around the point of original development. And development and growth continues. Now there may reach a point where the advantages of further growth (more social contact, more specialization) is balanced by the disadvantages (more congestion, higher cost of transportation, overloading of environmental systems, lack of access to open space). At this point, a group of individuals and firms may be able to do better in terms of their own willingness-to-pay by moving simultaneously to a new location and founding a new community, although it will not pay each to make the move individually (the firms need people, the people need the firms and other people). Of course, such a group could get together voluntarily and move, but the process of getting together is far from costless and a more efficient means of establishing this getting together could be through public action such as the New Towns program in England.*

* We shall return to problems associated with the provision of costly information in Chapter IV.

It is far from clear what the importance of this type of hypothesized market failure is. One is tempted to argue that it could be quite large and that a social structure based on a system of smaller, individually focused communities could leave everybodybetter off than megolopitan sprawl.(10) On the other hand, a wide spectrum of seminal nodes (existing towns) around which such development could occur by individually made decisions, exist--some of these alternatives are being taken advantage of (firms and people do move away from the large city) from which one may argue that most people are not operationally constrained by the locational decisions of others. We shall not attempt to resolve the issues here but will have cause to refer to this type of market failure in the sequel.

Summary of Market Failures

In summary, the price mechansim can breakdown in:

a) the allocation of collective goods,
b) the allocation of goods subject to decreaseng cost,
c) the allocation of goods subject to spillovers,
d) the allocation decisions in which contracting costs are large.

With collective goods, no individual has any incentive to let the government or the market know how much he wants of these different goods and how much in taxes he would be willing to pay to obtain them. Such a revelation would not significantly increase the quantity of goods for which he is forced to pay. With goods whose marginal costs of production are less than their average costs of production, private markets cannot efficiently produce and distribute the goods while at the same time making a profit, or even breaking even. Efficient distribution can only occur if the producer loses money and private enterprise will never undertake such operations.

Spillovers have no effect on market prices yet they are important to welfare. Important negative spillovers include the various forms of material and energy disposal. Since the market does not account for these spillovers, it will produce too much of goods subject to such third party effects. With positive spillovers,thesocial benefits of having an individual consume some particular good exceed the individuals private benefits.

Other individuals gain something from his consumption. Since any individual will base his private decisions on his private benefits and costs, the private market will not produce enough of these goods. Finally, problems with respect to informational and organizational difficulties in reaching contracts and collective decisions will result in certain possibly superior alternatives not being considered.

It should be clear from our discussion that the above categories are far from mutually exclusive. In fact, a close relationship exists between difficulties in exclusion, decreasing costs, spillovers and contracting costs*. We shall not examine this relationship nor attempt to establish that all private market failures can arise from a smaller, more general set of causes. It is more important to note that all the above type of failures are biased in the same direction.

Although the market may inefficiently distribute coastal areas, it is not randomly inefficient. Basically, the market will allocate too little of the coastline to recreational and other public uses because it does not reflect real preferences concerning collective goods, because they are often subject to decreasing costs and because positive spillovers are not considered. The market will allocate too many resources to those uses with negative spillovers because the social costs of these spillovers are not considered. Generally, this means too many resources will go to industrial uses. Market allocation mechanisms systematically result in the underproduction of public goods and a corresponding over production of private goods. In Galbraithian terms, this is the crisis of social balance. Reliance on the market will yield too many private goods and too few public goods.

For all of these reasons, some method must be found to supplement market allocation mechanisms. Market results must be modified on the basis of further considerations. In so far as the allocation of resources can be accomplished on a project by project basis, the technique for doing this is cost-benefit analysis.

* Demsetz argues that all market failures are explainable in terms of contracting costs. (11)

Cost Benefit Analysis

The problem then is to develop a methodology which will result in an allocation of resources which is consistent with the willingness-to-pay of the individuals in a society in the face of these market imperfections or, more concisely, a methodology which will indicate the Pareto-efficient allocation of resources associated with a specified (generally, the present) distribution of income.

Actually, given our previous rather lengthly spadework and development, or rather assumption, of the definition of what is socially optimal the indicated methodology is rather obvious in fact, it hardly deserves the title "analysis".

Definition:

THE GROSS BENEFIT OF A PARTICULAR INVESTMENT TO AN INDIVIDUAL IS THE MAXIMUM AMOUNT THAT THAT INDIVIDUAL WOULD PAY FOR THE OUTPUTS OF THAT INVESTMENT.

Thus, cost-benefit analysis assumes that all the values a man has for a particular good, whether it be a material good, an aesthetic good, or a psychological good, can be quantified by finding out how much of other goods he would be willing to forego to obtain the good in question. In a market economy we can measure the value of the goods foregone in money terms or dollars which can be thought of as a generalized claim on other goods, from bread to yachts, weighted by their prices. In the words of Dupuit, who first suggested this valuation scheme, "Unless there is willingness to pay, there is no utility (value)." (12) More formally, this valuation scheme is simply an extension of classical consumer theory broadened to include non-market goods.

This is not to imply that one can discover how much people are willing to pay for a good by asking them. For it is the nature of public goods that it is often rational for an individual to misrepresent his desires. If someone is asked how much he is willing to pay for air pollution abatement and he feels that his answer will not affect the amount he is actually charged, it will pay him to over-state his desires to make air pollution abatement more likely. On the other hand, if the question is aimed at determining how much he is to be taxed, it will pay him to understate his value knowing that differentials in his individual contribution will have almost no effect on the quality of the air. One of the problems then, in estimating the benefits of a public investment, will be to determine the real amounts a person would pay despite this systematic misrepresentation.

In the collective good type of investment with which we will often be dealing, one man's enjoyment of a particular good does not prevent another from enjoying it. In such cases, it is necessary to extend our basic definition to:

> THE TOTAL GROSS BENEFIT ASSOCIATED WITH AN INVESTMENT IN A COLLECTIVE GOOD IS THE AGGREGATE OF THE MAXIMUM AMOUNTS THAT EACH INDIVIDUAL USER OF THAT INVESTMENT WOULD PAY FOR ITS OUTPUTS

This is straightforward generalization of the basic premise, to the case where more than one person can use a particular unit of good; however, it emphasizes the dependence on our valuation scheme on the income distribution assumed. Someone earning $30,000 may be willing to pay more for some frivolous luxury than two or three people who earn $5,000 a piece in aggregate are willing to pay for medical care. Yet, it would be a barren ethical or moral system which held that a rich man's values are worth several poor peoples! The ethical and moral problems entailed in our valuation scheme are obvious.*

* Another problem, raised by Galbraith, is that in a modern economy peoples' willingnesses-to-pay can be changed by the purveyors of various commodities. Taking the position that peoples' willingness to pay, a variable demonstrably and seriously influenced by advertising, represents in some sense, a persons underlying preferences is more than a little uncomfortable. It represents a clear bias toward those goods with the most effective control over communications media. We shall return to this problem in Chapter IV.

Our second definition is derived from the basic observation that resources, including the coastal zone, are scarce; that is, in using a resource for a particular activity, we are giving up its use in any other activity.

Definition:

THE COST OF ANY ACTIVITY IS THE BENEFIT, AS DEFINED ABOVE, ASSOCIATED WITH THE OPPORTUNITIES FOREGONE DUE TO OUR ALLOCATION OF RESOURCES TO THIS ACTIVITY. WHERE MORE THAN ONE OPPORTUNITY OR SET OF OPPORTUNITIES IS FOREGONE, THE COST IS THE HIGHEST VALUED OPPORTUNITY OR ATTAINABLE SET OF OPPORTUNITIES FOREGONE.

In the literature, this concept is generally called the opportunity or social cost to distinguish it from the monetary outlays required to purchase this activity.*

The basic principle of cost-benefit analysis follows directly from the definition of benefit, cost, and Pareto-efficiency. In fact, it is merely a restatement of the condition for Pareto-efficiency.

THE ECONOMY WILL BE OPERATING PARETO-EFFICIENTLY IF IT PURSUES ALL THOSE ACTIVITIES FOR WHICH THE TOTAL GROSS BENEFIT IS GREATER THAN THE TOTAL SOCIAL COST.

Or, in other words, only if all resources are devoted to their highest valued use in terms of willingness to pay is it impossible to improve the situation in such a way that everybody will be made better off.**

* The adjective "social" in this sentence has no political implications. It connotes that we wish to include the costs to all individuals in society of an activity in our calculations. A more neutral synonym would be "total".

** We would be the last to argue that the above outline represents a complete justification of the foundations of cost-benefit analysis. The purpose of this report is to apply rather than to describe a cost-benefit analysis. Those readers who are interested in a through discussion and justification of cost-benefit analysis rather than the bare outline presented in this section are referred to in references (13),(14), and (15).

Our problem then is conceptually simple: Find out how much people are willing to pay for an particular use or mix of complementary uses of a resource in each of the years during which the resource is committed to this use, find out the social cost through time of each of these uses and allot that resource to the highest-valued use.

Unfortunately, the problem of determining how much people are willing to pay is usually anything but simple, requiring in many cases a great deal of ingenuity, while in others is so difficult that it is not worthwhile. In which case it may be quite useful to perform that analyses over a range of postulated benefits to discover which alternatives are consistent with which assumptions about people's values and to screen out projects which are not efficient under any reasonable set of assumptions about values.

Usually, the problem of determining the opportunity costs of an activity is somewhat simpler for, even in a partially competitive economy, the market price of a resource being employed in a particular use can be a reliable measure of its social costs. However, we shall see that we will have to tread carefully in this regard also.

Present Value

The above base outline of cost-benefit analysis must be modified to take into account people's preferences toward time. The existence of an interest rate indicates that people prefer consumption of a benefit now to consumption of the same benefit later; for unless people preferred a $1.00's worth of consumption now to ($1.00 + i)'s worth of consumption a year from now, it would be impossible to maintain an i% interest rate.* On the cost side, if we delay an investment in, say, a beach for a year, we will be able to use the resources that would have gone into a beach elsewhere for a year. Therefore, the social cost of building the same beach a year from now is less than the social cost of building the beach now.

* This section assumes no price changes with time, no inflation or deflation. Thus, the interest rate referred to is the inflation-free interest rate. Inflation does not substantially change the following argument, although it does present some problems in determining what the actual interest rate is in an economy.

The proper technique for handling this effect of time is to evaluate all the benefits and costs which will be experienced in year t, weight them by the factor $D_t = 1/\prod_{m=0}^{t} (1+i_m)$ where i_m is the interest rate in year m which interest rate simultaneously represents the economy's feelings about the relative value of consumption at the beginning and end of year m and the marginal opportunity cost of capital during year m. This weighting procedure is known as discounting. After discounting, all the discounted benefits and the discounted costs are summed over time to yield what is known as the net present value of the project. In symbols the present value equals:

$$V = \sum_{t=0}^{N} D_t \cdot B_t - \sum_{t=0}^{N} D_t C_t$$

where:

V = net present value

D_t = discount factor for year $t = 1/\prod_{m=0}^{t} (1 + i_m)$

B_t = value of benefits experienced in year t

C_t = value of costs incurred in year t. Costs should be measured on a net cash flow basis, capital expenses being realized in the period when they actually occur. The discounting procedure automatically takes care of amorization and interest charges.

N = Lifetime of project

By an extrapolation of the argument for our basic principle it can be shown that, if an economy wishes to operate Pareto-efficiently, projects with a positive net present value should be undertaken; projects with a negative net present value should not be undertaken. If this rule were followed for all possible sets of projects, the country would be achieving economic efficiency.

It would be maximizing the size of the economic pie, given its limited set of resources.* There would be no alternative development pattern that everybody would feel happier with given the postulated distribution of income, and in implementing each of the projects indicated, it would be conceptually possible to compensate those people who are affected negatively by the project sufficiently so that they judge themselves no worse off than before. Proofs for this thesis are given in references(13) and (14).

Choice of Interest Rates

In a perfectly functioning, risk free economy determination of the interest rate to be used in assessing projects would be no problem since such an economy would be able to support only one interest rate which would simultaneously measure peoples' attitudes about consumption now as opposed to consumption in the future and the value of the opportunities for investment in the private sector. (16) In an imperfectly competitive economy such as ours a whole range of interest rates can exist. In such a situation, the problem of choosing an interest rate becomes difficult and sometimes a critically important decision.

* In less prosaic, but considerably more fanciful terms, the economy would also be maximizing a variable we might call net national social product which would differ from the standard descriptions of national accounts in that (a) it incorporates and values the spillover costs and benefits associated with the resulting allocation. (b) it incorporates the values that people place on--the amounts they are willing to pay for--public goods which may or may not be provided free of user charge. We do not mean to imply by this digression that the state of the art in cost benefit analysis has presently advanced to the stage where an attempt to actually measure the net social product of the economy would be a useful exercise. It has not. However, consideration of such a concept is useful in clarifying our thinking about what is wrong with present national accounts as descriptions of standard of living. They leave out spillover costs and undervalue public goods. It also says something about the design of "social indicators" a subject that has recently received some attention (17).

The basic principle is that the interest rate in public project evaluation must be the same as that assigned by the private market to the resources and benefits which will be used in and accrue from this project. If a higher rate is used by government, then public projects will fail to be adopted which are more highly valued than the private uses of the resources required for this project; if a lower rate is used, public projects will be adopted where the capital could be used for purposes of private investment or consumption that are highly more valued by the economy. As Baumol puts it, "The correct discount rate for the evaluation of a government project is the percentage rate of return that the resources utilized would otherwise provide in the private market." (18) The rate of return referred to is the before tax rate of return, for taxes are merely transfer payments from the owners of the resource to society in general.

Now due to differing patterns of taxation, legal restrictions, lags in adjustment, differing access to opportunities, resources can earn a different rate of return in different parts of the economy.

Baumol shows that in this case one should use the weighted average of the rate of return for the various sectors of the economy from which the public project would draw its resources. (18) Thus, the appropriate interest rate would be lower if a public project, for some reason drew all its resources from consumers than from the production sector of the economy, reflecting the fact that consumers generally have a lower opportunity rate of return than industrial concerns. If, as is generally the case, the project draws resource from both sectors than a weighted average should be used.

The foregoing discussion ignores two problems, inflation and risk. Inflation is fairly easily disposed of. If inflation is expected to occur during the lifetime of the investment, one has the option of adding the inflation rate to the interest rate (as the private market does) and inflating future costs and benefits according to this inflation rate. Alternatively, one can attempt to determine the inflation free interest rate, the so called real rate of return, and use constant prices and values in evaluating the costs and benefits throughout the life of the project. The results will be identical whichever method is used. We will generally follow the second course.

The effect of risk on interest rates is the subject of some controversy in the economic literature at present. It has been observed that risky investment generally demands a nominally higher rate of return. In the sequel, it is argued that the bulk of this excess is required in order to to give risky investment the same expected rate of return as riskless investments and thus, in consonance with Baumol's principle ennunciated above, it is this average rate of return which should be used. In so far, as risky investments demand a higher expected rate of return than riskfree(such a difference would be required if investors are risk adverse), there may be an argument for not using the higher expected rate of return as the interest rate in evaluating public projects on the grounds that, even if individual investors are risk adverse, society as a whole should be an expected value decisionmaker. We shall talk about this more later. But for now we merely note that this difference between the expected rate of return required by investors on risky investments and the rate of return on riskfree investments, the so-called risk premium, is much smaller than the difference between the nominal rate of return on risky investment and the riskfree rate of return. If this is true, the weighted average return will be approximated by the riskfree rate of return. In this report we will be using constant-base (1970) prices rather than current prices, thus we require the real, pretax rate of return.

With corporate rates of return averaging 10-12% and riskfree private investment opportunities of 8-9%; assuming a 4% inflation rate, leads to appropriate real interest rates of the order of 5 to 8%.

It is not the purpose of this section to pick an interest rate but only to outline the principles by which it should be chosen. We will use 5% in our exemplary calculations. Often it will pay the analyst to calculate the net present value of the alternative projects over a range of interest rate and display the sensitivity of the alternatives to this parameter. For after all, even if one can determine exactly what the present opportunity cost is of the capital being employed in the project-generally not true-the future interest rates are random variables which cannot be predicted with certainty.

Past government application of cost-benefit analysis has tended to make the mistake of using too low an interest rate, an interest rate considerably lower than the risk-free opportunity cost of capital in the private market. In the past, interest rates as low as 2-1/2% were used. However, it is easy to go too far in the opposite direction. In any event, the special nature of public goods should not be reflected in a low interest rate, but in the measure of benefits. Benefits should be correctly measured and private market evaluations should be augmented. Interest rates should not be lowered.*

Interest rates should only be lowered if society decides that it is consuming too much and investing too little in both the private and public sector, in which case effort should be made to increase both public and private investments to bring the rates of return in both areas down. Thus, it is possible to argue that the interest rate reflects too high a rate of time preference, but this argument must be applied to both private and public investment. The corollary is that the society ought to lower the percentage of its output that goes to all current consumption (public or private) and raise the percentage of its output that goes to all future consumption (investment, public or private).

Since there is almost no evidence that society wants to radically shift its investment-consumption

* Low interest rates for public projects have been defended in the past on grounds that government has a special responsibility to unborn generations which the private market does not. This may be true, but, if so, it should be reflected in the future benefits of the project which, properly calculated, will include where applicable, the amounts that presently unborn people will be willing to pay some time in the future. Thus, our choice of an interest rate is not biased against future generations. Rather, it assumes that these future generations will value immediate over subsequent consumption in approximately the same manner as their forebears.

mix, all coastal projects should be capable of earning a real rate of return of 5 to 8%. A real rate of return in this context does not, of course, mean a money rate of return of this amount. Many of the public benefits that are embodied in the real rate of return of, say, 8% will not be recoverable in money terms.

Parochial Benefits

In measuring benefits, it is extremely important to distinguish between the direct and indirect effects of a particular coastal zone project. The direct effects are those which accrue to the consumers or users of the project, the users of the power supplied by a coastal generating plant, the bathers on a beach, the swallowers of polluted air, the inhabitants of a coastal housing project, the viewers of marsh wildlife The indirect effects are those that accrue to the suppliers of the resources which make the investment possible. These include the payments made to the construction workers and maintenance personnel, sellers of material and land, and in turn the payments that these groups make to bar owners, retailers, and so on.

Consider the construction of a nuclear power plant on the shoreline. The plant will output electricity, heated water and some chemical wastes, a visual impact on the surrounding area, etc. These are direct effects and the value that the individuals in the affected region place on these effects measures the various benefits and disbenefits of this development.

The construction and operation of the plant will also require a number of inputs including land, labor and material. The value of these resources diverted to the plant is the cost of the development. Of course, these resources must be paid for their employment for they must be bid away from other uses. The nuclear plant construction worker will receive a sum of money for working on the plant and this is certainly a benefit to him. Further, he will spend a substantial portion of his pay in the locale of the plant, and this is certainly a benefit to the local merchants, doctors, and tavernkeepers. These people in turn will spend some of this money in the locale and so on. The same argument could be used for the expenditure on any other input. Values which arise in this manner we shall term parochial benefits. The question then is should we count all or part of the costs of the plant as a benefit on the grounds that people in the locale would be willing to pay something to see these expenditures take place ?

From the point of view of Pareto-efficiency the answer is no, given full employment. For with full employment, the fact that one has to pay a construction worker $6.00 per hour to work on the plant means he was worth $6.00 per hour elsewhere. Thus, his employment on the plant means a loss to some other project. Similarly, the parochial benefits which accrue to the locale of the plant from the construction workers' expenditures would accrue no matter where the plant was located. Of course, different shopowners would see this money if the location were changed. More generally, wherever the money (resources) were spent, be it on a plant or something else, approximately the same parochial benefits would accrue. Thus, from the point of view of the economy as a whole, parochial benefits are a wash. One can change their geographical incidence but they do not represent any net economic values to the society. Rather, they represent a transfer payment from the entire economy to a more localized area. Given full employment, the costs of a project cannot be counted as a benefit. To do so is a subtle form of double counting with which almost any project could be justified.*

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* Another way of looking at this problem is as follows. We could attempt to estimate how much the people in the locale would be willing to pay to see the expenditures associated with the plant take place in their locale and then include this willingness to pay in the benefits. But, if we did this, we would also have to estimate what people in other areas would pay to see the plant or an equivalent investment take place in their locale and include this willingness to pay among the disbenefits or costs of the project. Barring large differentials in unemployment (see below) the parochial benefits associated with one location will be about the same as the parochial benefits associated with another location. Hence, these too sums will cancel. This is what we mean by a wash. And we can save ourselves the computational difficulties of trying to estimate these quantities by leaving them out of the analysis altogether.

It is in the nature of things that even in a substantially full employment economy a large percentage of resources is underemployed at any given time, due to lags in adjustment. The physician in the locale of our hypothetical power plant will experience an increase in his practice as the result of the plant's locating there and, if he were underemployed to begin with, he would be willing to pay (our definition of benefits) for this increase. Similarly, an underemployed retailer or barber might be willing to pay for the location of the power plant nearby. Even this sort of underemployment is not sufficient argument for the inclusion of these benefits in our net present value calculations for, in general, there will be similarly underemployed citizens wherever the plant is located. What is necessary if there is to be a net benefit to the economy as a whole arising out of one of these parochial benefits is differentials in underemployment. In an economy such as ours, it is unlikely that significant differentials in underemployment can last very long and we feel that it will rarely be necessary for a body representing the economy as a whole to spend much time investigating them.**

However, parochial benefits can be overwhelmingly important to political bodies representing small portions of the economy. If differences in the geographical incidence of the parochial benefits associated with a particular investment, whether public or private, shift these benefits outside of the area the political body represents, this area suffers a very real loss. As a result, a local community can <u>rationally</u> view a project in a very different manner from the region as a whole, even if no local spillovers are involved. What is a wash to the entire economy can be something for which a locality within that economy may rationally be willing to pay a high price. Whether a parochial benefit is a wash or not to a political body will depend on the range of the responsibility of the political body involved. For example, differences in the location of a refinery within Maine will give rise to differentials in the geographical incidence of parochial benefits which will be extremely important to the communities considered for the location of the

* It is ironic that when people talk about the "economic" benefits of a project, they are almost always referring to these parochial effects which with the help of economic analysis we can see are not net benefits at all to the society, at least in terms of Pareto-efficiency.

refinery but which will be a wash from the point of view of the state of Maine. On the other hand, the decision of whether or not to build a refinery in Maine will give rise to parochial benefits which will have a net effect on the Maine economy but which are washes from the point of view of the country as a whole.

It is instructive to note that private markets and the price mechanism give no weight to parochial benefits at all and, in the absence of collective goods, spillovers and contracting costs result in a Pareto-efficient allocation of resources. Parochial benefits, on the other hand, are a completely arbitrary concept defined by and changing with the boundaries of the political bodies involved. Given this arbitrariness, we should be surprised if the counting of parochial benefits (however defined) leads to an efficient allocation of the coastal zone and it is easy to see that, in general, it will not.

Parochial benefits are the reason why communities compete with each other for large private or governmental installations. A result of such competition is that a developer can use these parochial benefits to implement projects which are inconsistent with society's values. For example, let us assume that society judges the spillover costs of a coastal power plant so high that the net present value of the plant located anywhere along the coast is negative. However, the market situation is such that the plant is profitable to the developer. Assume further that the coast is controlled by the local communities. The developer can approach the local communities and point out that, if we build the plant in your town, the locale will receive the bulk of the parochial benefits of the plant. This localization of the parochial benefits may make it rational for the town to accept the plant, although to the society as a whole it is a disbenefit on net. Furthermore, since towns will compete with each other for these parochial benefits, the developer can bargain for the most favorable zoning laws, taxation, etc. In such bargaining the large-scale developer is generally in a much stronger position than the typical coastal town and often can pretty much write his own ticket. He can even find situations which would be privately unprofitable in a free market which can become profitable through this kind of bargaining.* Thus, parochial benefits can lead to overdevelopment, even in the absence of any negative spillover effects.

In using parochial benefits in this manner, the developer is employing transfer payments from the entire society to the locale of the development as a lever. He is not creating any net values. He is simply transferring income from one diffuse group to a much more localized one.**

Examples of the misallocations that can occur through this mechanism are numerous.

Their are two possible remedies:

1) Ban the formation of political bodies (formal and informal) which have the power to affect development decisions, that is return to a strictly private market situation. This would prevent the operational expression of parochial benefits. It would also exacerbate all the private market failures outlined earlier, which were, at least in part, the reasons for the formation of most of these bodies. We do not consider this an alternative worth considering in general, although there may be some cases in which forbidding political control over certain types of decisions results in more efficient allocation of the coastal zone.

2) Make sure that the political body affecting any particular sort of development is broadly based

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* The Litton Westbank shipyard in Pascagoula, Mississippi may be a case in point.

** Parochial benefits can also arise on the output side in some coastal zone developments; that is, some developments have the property of localizing payments for the outputs of a development in the same way that construction and operation necessarily localizes payments for the inputs. Recreation facilities are often of this category. The money people spend on a recreational activity, say a World's Fair, and the respending of these expenditures are localized in the area of that activity for which localization the community--as opposed to the recreators--in question may be willing to pay a great deal. This is the basis for state and local tourist bureaus. It should be clear that the same argument applies to these benefits as to parochial benefits arising on the cost side. In general, they are not net benefits to the economy as a whole.

enough so that the bulk of the parochial benefits are a wash within its political boundaries. For decisions concerning the location of a gas station, the local zoning board is quite cognizant of the fact that approximately the same employment and taxes will occur wherever the gas station is located and will properly concentrate on the spillovers associated with the station. For decisions concerning the location of a large refinery complex, even a statewide decisionmaking body may not be sufficiently broadbased to bargain with the developer on the basis of outputs rather than inputs. We will return to this issue in Chapter IV;but,clearly,accountability and responsiveness argue that in any situation, the decisions should be made by the smallest political unit for which the net parochial benefits associated with this decision are unimportant.

For now, the two basic points with respect to parochial benefits are:

1) Given full employment or evenly distributed underemployment, the effects of shoreline investments on the suppliers of the resources enabling these investments should not be counted in net present value calculations, if we are to efficiently allocate the coastal zone.

2) Parochial benefits are benefits on net to the localities involved, and a political body representing these localities rationally considers these effects in representing its constituents. As a result, decisions emanating from these bodies will not, in general, be efficient.

Unemployment

If there is widespread unemployment, then the above statements will have to be altered slightly. Unemployment is a situation in which the private market overestimates the social cost of labor. Technically, unemployment is the situation where, at the market wage rate, the supply of labor is greater than the demand. In a perfectly functioning competitive economy, this would be a temporary situation. The wage rate would quickly drop to the rate at which supply would equal demand, which lower rate we will call the shadow price of labor.

The shadow price of labor will be the point at which any further decrease in the wage rate will result in the person's finding employment elsewhere at which alternate employment his wage is worth the shadow price..

In short, the shadow price of labor is the social cost of labor. If there is a significant difference between the market wage rate and the shadow price of labor (if there is substantial unemployment), then the cost-benefit analyst should use the shadow price rather than the wage rate, if we are to allocate resources according to Pareto-efficiency.

In other words, unemployment should be handled not by postulating a secondary set of benefits and including them in the analysis, but by adjusting the costs of labor on the project to reflect the social cost to the economy of the employment of said labor on the project being analyzed. Thus, increasing unemployment will decrease the social costs of labor which will increase the number of projects which have positive present value. Certain projects which were inefficient under full employment will become efficient with a rise in unemployment. Since the U.S. economy is at sensibly full employment, we do not feel that there is any great need to attempt to develop shadow prices for labor in evaluating coastal zone projects at present, unless this coastal zone project intends to make substantial use of groups which have much higher-than-average unemployment rates, such as the ghetto poor. No such examples are considered in the sequel of the report. Therefore, we will value labor costs at the market rate for the remainder of this volume.

Uncertainty

A common demominator of almost all major shoreline development alternatives is uncertainty. This is especially true with respect to the development of biologically active areas, for the impact of development on the marine and coastal ecology is very poorly understood. Another basis of uncertainty which is at least as important and, on the basis of past performance, even more likely to be overlooked arises from the fact that, in order to effect cost-benefit analysis, we must predict how people will value various ecological effects in the future. Obviously, we cannot do this with certainty. For example, it would have taken a prescient individual indeed to predict in 1940 that the American people would pass a law in 1966 which showed that they were willing to pay $3.00 per ton of garbage to reduce the air pollution due to garbage incineration.

In past economic analyses, uncertainties have been given lip service at best. This is a crucial oversight in such areas as conservation, where the costs of guessing wrong can be high indeed, for many development alternatives are essentially irreversible. In this section, we wish to argue that means for handling these uncertainties and thus trading off the benefits versus risks of different development alternatives are available, and to point out some of the practical difficulties involved in the implementation of these techniques.

For example, consider the possible development of a marsh. Let us assume for simplicity of exposition that there are only two time periods and two possible outcomes relevant to this problem. Call the times Now and In the Future. The decision Now is whether or not to develop the marsh. Whatever we do In the Future we will become aware of the value of the marsh and, again for simplicity, we will assume that, with respect to the value of the undeveloped marsh, there are only two possible outcomes:

1) In the Future the undeveloped marsh is revealed to be valuable.

2) In the Future the undeveloped marsh turns out to be not so valuable.

Let us assume that the present value of the gross ecological, scenic, and other nonmarket benefits of the undeveloped marsh in the first case is 15 units, while in the second case it is 2 units. Let us assume that the net benefits, exclusive of these nonmarket values, which will be derived from development Now and valued at 12 units and, further, that the present value of these market benefits, given that we develop the marsh In the Future, is 8 units. We will also assume that, once the marsh is developed, the costs of restoring this marsh are higher than the benefits from restoration, even if the marsh is shown to be valuable. This is the typical case and what is usually meant when people say a development is irreversible.

Given this hypothetical situation, the possible consequences of our present choice can be illustrated by the decision tree shown in Figure 2.2. The boxes in this diagram represent decision points and the circles, outcomes determined by chance. The break lines indicate alternatives which we have assumed have been ruled out by earlier analyses. Thus, the top branch in the tree indicates that, if we develop Now and the marsh is revealed to be not so valuable, we will receive the net market benefits of the development and lose the non-market benefits of a not-so-valuable marsh for a present valued gain of twelve and a loss of two, or a final net present value of ten. Similarly, the net benefits

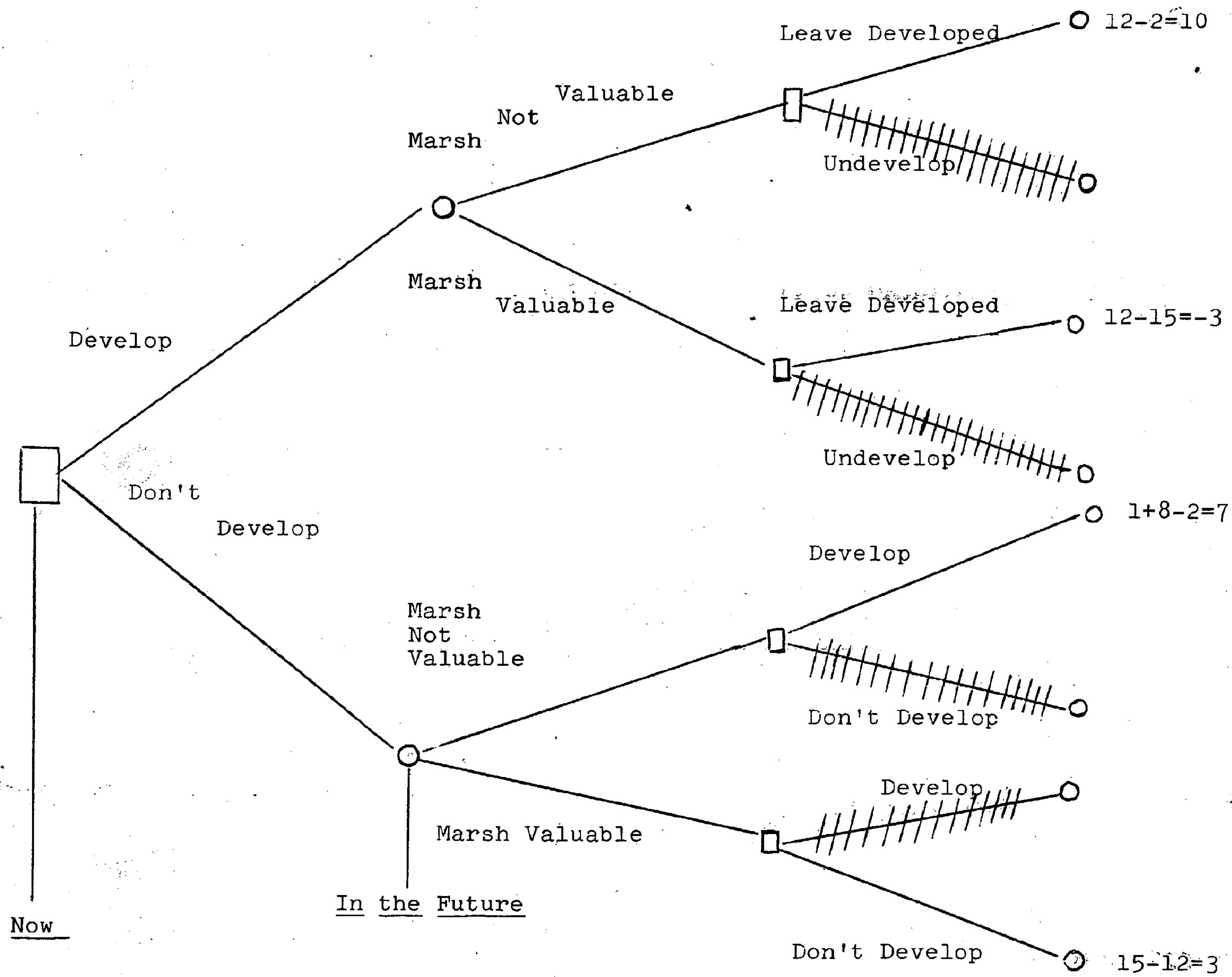
Develop
Don't Develop
Marsh Not Valuable
Marsh Valuable
Leave Developed
Undevelop
12-2=10
12-15=-3
Marsh Not Valuable
Marsh Valuable
Develop
Don't Develop
1+8-2=7
15-12=3
Now
In the Future

FIGURE 2.2

of the other combinations of a decision and an outcome are placed at the ends of their respective branches. In so doing, we have valued the non-market benefit of a not-so-valuable marsh between Now and In the Future at one unit.

Given this situation then, what should we do? Clearly, that depends on two sets of judgments:

1) The community's judgment of the likelihood that the marsh will turn out to be valuable either because of its ecological properties or because people in the future decide the scenic and esthetic values of the marsh are valuable. The more probable this outcome, the more attractive the upper branch becomes. Conversely, the lower the probability that the marsh is valuable, the more attractive development Now becomes.

2) Even if the community can agree on the likelihood of the various possible valuations of the marsh, in general it will not be immediately clear which alternative is most consistent with the community's set of values. The upper branch of this tree is the high-risk, high return alternative. The lower branch assures us that we will obtain at least three units, but no more than seven. If the community is extremely risk-adverse, it may prefer the lower branch, even if the probability of the marsh being not valuable is quite high. If, on the other hand, the community is made up of a set of long-shot gamblers, then, given the same likelihood, it may rationally choose the chance at ten units which the upper branch offers.

With respect to society's attitudes toward risk, the usual assumption is that society is risk-neutral;that is, it is indifferent between any fair bet. This implies, for example, that the community is indifferent between an alternative that offers a net present value of $\$10^6$ with certainty and one that yields at 50% chance at $\$2 \times 10^6$ and a complementary chance at $0. If this is the case, the community is said to be an expected value decisionmaker.

Most people are risk-adverse. Given the above choice, they would unhesitatingly take the million for sure. In fact, most people would prefer $800,000 for sure to an even chance at two million. Most people are not expected value decision-makers and with good reason.

However, as the amounts risked become small with respect to the individual's wealth, most people approach expected value decision-making. One of the advantages of political organization is that it enables individuals to share their risks. Thus, from the point of the economy as a whole, most shoreline development alternatives involve values that are small compared to the region's wealth, and in these cases expected value analysis will be appropriate. This may not be the case if the resources risked are extremely rare or unique. Expected value analysis with respect to the preservation of the bald eagle is almost certainly not appropriate. In such a case, there is no choice but to attempt to measure society's attitude toward the risk in question, either by extrapolation from other similar situations or by referendum. However, while marshland is rapidly decreasing, it can hardly be called rare or unique. Thus, for the present, expected value analysis seems indicated for most shoreline development projects under uncertainty.

In order to perform expected value analysis, the earlier equation for net present value must be generalized to the following form:

$$\bar{V} = \sum_{t=0}^{N} D_t \cdot \left[\sum_{k=1}^{N_t} p_{kt} \cdot B_{kt} - \sum_{k=1}^{M_t} q_{kt} \cdot C_{kt} \right]$$

where N_t is the number of possible values that the benefits may take in year t and M_t is the number of possible values that the costs of the alternative in question may take on in that year, and p_{kt} is the probability of the k^{th} possible benefit value in the t^{th} period and q_{kt} is the probability of the k^{th} cost value in the t^{th} period. If the community is an expected value decision-maker it should choose those alternatives with positive $\bar{V}$, or, in the case of a set of mutually exclusive alternatives, that alternative from this set with the largest positive $\bar{V}$

Notice that this is a much different approach than the sometimes suggested idea of:

a) Assuming that the most probable sequence of event occurs,
b) Adding a risk factor to the interest rate.

Assuming that the most probable sequence occurs immediately begs the basic question that different alternatives may have very different abilities to react to the occurrence of events other than the most likely event.* Different alternatives can have different degrees of flexibility. Assuming that the most probable sequence of events occurs completely undervalues this flexibility. In the sample marsh problem, the basic trade off involved the fact that, if one did not develop now, it was relatively easy to develop in the future. However, if one did develop now, then adjusting to the event Marsh Valuable was prohibitively costly. Assuming that the most probable sequence of events occurs ignores this basic consideration entirely.

Moreover, the idea of assuming a sequence of events and adding a risk factor to the interest rate is not only an extremely poor substitute for actually tackling the fact of uncertainty, but also once one has so attacked the problem and assumed that the community is an expected value decisionmaker, it is inconsistent. Even if one is risk-adverse, the addition of a risk factor has no solid foundation. Methods for handling this problem are given in reference (19) . The use of a risk factor grew out of the perfectly reasonable practice of banks demanding a higher interest rate on risky loans. If one does an expected value analysis and assumes that the banks want to make the same amount of money on the average from all their loans, a necessary condition for the bank to be an expected profit maximizer, then it will be clear that they have to raise the price of their commodity on risky loans for the expected repayment, as opposed to the nominal value of the loan, on a high risk loan is lower than the expected repayment on a low risk loan. The change in interest rate is a product of the analysis of uncertainty, not a substitute for it.

We are now in a position to comment in more detail on the argument that the nominal rate of return on risky investments should be used as the interest rate in present value determinations, rather than the risk-free rate of return.

First of all, Baumol's argument that the nominal rate of return should be used is inconsistent with his recommendation of using the weighted average of the rates

* Usually, the most likely chain of events is itself a very low probability set of occurrances.

of return in the sectors from which the project's resources are drawn for, if we find one investment obtaining a return of 20% in a particular risk environment, then elsewhere in that same environment we will, with high probability, find investors obtaining less than average or even negative returns. If not, capital would flow to the area with the average higher-than-average rate of return. (Of course, companies often attempt to use risk as justification of high profits resulting from monopolistic positions or beneficial taxation policies when no such risk exists in fact.)

Secondly, the argument that individual risk is different from social risk appears to be based on a misinterpretation of the law of large numbers. If one makes a large number of risky decisions, the law of large numbers does not assure one that, with the high probability, the final gain (loss) will be close to the expected gain(loss). In fact, the probability of getting further and further away from the expected outcome increases with number of investments. The law of large numbers rather says that the average gain (loss) <u>per investment</u> will, with high probability, be close to the expected gain (loss) <u>per investment</u>, which is something quite different. It is not the law of large numbers alone that assures the profitability of an insurance company but the law of large numbers, combined with the risk aversion of its clients, which makes them willing to pay a premium (given the insurance company a bet with positive expected value) in order to avoid certain situations with large personal losses. If people were only willing to make fair bets with insurance companies (bets with 0 expected value), sooner or later the insurance company, however large, will be ruined. From this point of view, it is not clear at all that society shouldn't be willing to pay something to avoid risks.

However, we would be the first to admit that in many situations society can afford to be an expected value decision-maker when the individual cannot, in which case the society should use the expected return on a risky investment in calculating its opportunity cost while an individual might evaluate the return at something lower when comparing it with a riskfree investment. For society, like our insurance company, has a large number of positive expected value investments each of which are small compared to the assets of society as a whole. And, in fact, we shall use expected value analysis in the sequel.

However, there is a broader sense in which society is not in the happy position of our hypothetical insurance company--situations in which a good deal of social risk adversion might be prudent, situations in which the individuals of the society as a whole might be willing-to-pay a great deal for insurance. Many ecologists have pointed out that we have attained the ability to produce large scale changes in our environment with consequences we are as yet unable to predict. Not all the bets that we can make with our environment are still small compared with our total assets. Odum, among others, has emphasized that those ecosystems which maximize productive efficiency under a particular set of circumstances--monocultures based on grazing food chains (plant-hervivore-carnivore sequences) rather than reuse of detritus--are just those ecosystems which are most vulnerable to exogenous changes in the environment.(20) In short, generally the most efficient systems are the ones which offer us the least protection to biological perturbations. The question then is how much are we willing to pay for stability in the face of uncertainties about the consequences of our actions? We will not go into this problem in this report but merely note that if some of the possible consequences are of world-scale or even area wide magnitude, expected value analysis is probably inconsistent with the desires of a society make up of risk adverse individuals.

A useful analogy may be made with the actions of insurance companies with respect to hurricanes. Meaningful hurricane insurance cannot be purchased in such areas as the Florida Keys even though a large number of potential insurers are willing to give the companies clearly positive expected value bets. For the companies realize that if the unlikely event of a much higher than expected frequency of hurricanes occurs, then losses will not be small compared with their assets.* Society might also be unwilling to take such bets. Thus, hurricane protection projects with negative expected present value may be consistent with willingness-to-pay. In summary, the restrictions on expected value analysis should be kept in mind in all that follows. Expected value analysis should not be accepted as uncritically as it has been in the few economic analyses which do exist which have attempted to include uncertainty in their

* It should be noted that the independence requirement of the law of large numbers is violated in this case. It can also be violated with respect to society in general. For example, consider insurance (deterrence assuming deterrence is effective) against war.

analysis in a meaningful way.

The Problem of Finding Society's Probabilities

Given that one is prepared to assume that, in the situation under analysis, society is an expected value decisionmaker, then one is still faced with the problem of coming up with society's probabilities on the possible consequences which can emanate from each alternative. If the community were an individual, this would be no great hurdle. In the hypothetical marsh example given above, one would simply ask the relevant individual whether he would prefer a 50/50 chance at $1,000 or a lottery ticket which gave him $1,000 if the marsh were valuable. If he prefers the former, that individual's subjective probability on the marsh being valuable is less than one-half. One might then ask this individual whether he would prefer a 25% chance at $1,000 or the marsh lottery ticket, and so on, until one obtained the point where the individual was indifferent between x% chance at $1,000 and the $1,000 if the marsh is valuable. If one accepts a very small set of intuitively appealing axioms about rational behavior under uncertainty (see reference 21), x is this person's probability that the marsh will be valuable. In general, of course, there will be many more than two possible outcomes relevant to a shoreline development. In fact, there will often be a continuum of possible outcomes, but this method can be extended to these cases with no conceptual difficulties.

The problem rather is specifying a probability distribution over the relevant outcomes for a community. Given our interrrogation method, one citizen can have an entirely different set of probabilities over the same set of outcomes than another citizen. In the vernacular, this is what makes a horse race.

At present, there has been no satisfactory analytical attack on the problem of communal probability distributions. The best advice that can be given now is that the community approach an expert or group of experts on, say, marsh value and ask them to come up with the possible outcomes and relevant probabilities of these outcomes. This approach has been successfully followed in a number of industry problems. In practice, one finds that the experts will start out with somewhat differing probability distributions on the random variables in question, but, if they are allowed to communicate, they will reach a distribution they can all agree upon. If not, the community or its representative must weight the differing opinions and generate a distribution in this manner.

As inelegant as this method is, it is in our opinion far superior to the usual alternatives of:

a) Ignoring uncertainty and proceeding with cost-benefit analysis as outlined above. This can lead to gravely inefficient allocations of the shoreline.

b) In the face of uncertainty, throwing up one's hands and turning the allocation problem back to the market.

In the exemplary problem in Chapter 3, we will attempt to substantiate this viewpoint.

Budget Constraints

Ideally, investment projects (public and private) will be undertaken in such a way that the real (money plus non-monetary benefits) rate of return on each project is equal to the society's opportunity cost of capital. Often in government agencies there may be certain budget restraints imposed even though the real rate of return on some government projects exceeds the economy's opportunity cost of capital. There just may not be enough budgetary resources of a certain agency to undertake all of the investment projects that ought to be undertaken by the agency.

In this second-best situation a method must be found to find an efficient allocation system, given the artificial budget constraint. Benefit-cost analysis can still be used but it must be modified. The opportunity cost of capital is higher for that agency than for the society. (This implies its budget should be increased.) In order to pick from its alternatives, given this budget constraint, the agency should increase its interest rate until it finds that set of projects with positive net present value, given this increased interest rate, which just use up the amount of available money.

Proceeding in this way, the agency can make efficient use of the resources, given that he faces budgetary constraints and it is not able to invest to achieve social balance.

Thus, in coastal allocation decisions it may be impossible to undertake public projects that provide the most efficient use for a particular site, due to budgetary constraints. In this case, estimates must be made of when the public project could be undertaken and the benefits of the project discounted accordingly. If the project is delayed far into the future, other projects will, of course, become the most efficient use for the site, even though they do not have the highest net present value given the social interest rate.

Conversely, if an agency finds that, at society's opportunity cost of capital, it does not have enough projects within its charter with positive present values to use up its budget, then it should not use all the resources it has been alloted and return the excess budget to the public coffers to be used elsewhere. Of course, we are not naive enough to believe that this is what happens under the present set-up, but the principle still stands and does point toward certain institutional improvements.

Cost-Benefit Ratios

Several authorities (13), (14) have demonstrated that the practice commonly used in the past of dividing the gross present value benefits by the gross present value costs and ranking alternatives according to the value of this ratio can be inconsistent with Pareto-efficiency, that is, inconsistent with willingness to pay. Given mutually exclusive investments, cost benefit ratios can pick less highly-valued projects over more highly valued, will often pick a less-than-optimal scale of a given project, and are subject to important ambiguities. Even the argument that net present value ignores risks associated with scale is no longer applicable, if we incorporate uncertainty into the analysis explicitly as outlined above. We regard the disadvantages of cost-benefit ratios as conclusively demonstrated and will make no further reference to the concept in this report.

A Final Caveat

This chapter has dwelt in considerable detail on the imperfections of the private market with respect to Pareto-efficiency or individual willingness-to-pay as a social goal. However, to say that the private market does not yield efficient results in all instances is not to say that it should be ignored or eliminated. Typically, any analysis will start with the results which would be produced in the private market. These results need to be modified in many cases, but they are almost always the correct place to start. If the results do need to be modified, the government is faced with two options--undertake projects directly, or try to modify private market decisions so that they are in accordance with social benefit-cost calculations. Often, this means changing the structure of the market either institutionally (public corporations, for example), or providing tax or expenditure subsidies which lead private decision-makers to choose projects which are Pareto-efficient. There is no general rule to determining which of these methods should be used.

The choice of methods is in itself a decision that can sometimes be analyzed from the point of view of benefit-cost analysis. Typically, society will want to use the method which generates the desired social benefits at the least cost. Sometimes this will be direct government expenditure, sometimes a public corporation, sometimes tax incentives, and sometimes expenditure subsidies.

CHAPTER III

EXEMPLARY COST-BENEFIT ANALYSIS

Introduction

For our exemplary problem, we have chosen to analyze the desirability of developing one of the Boston Harbor islands, Lovell Island, for waterfront recreation. Since this example is presented as a means of illustrating the practical problems involved in cost-benefit analysis rather than to determine the desirability of the actual investment, we will make free use of assumptions and hypotheses, especially in developing our cost data. In an actual implementation, such assumptions would have to be validated by detailed costing procedures. Three other examples of coastal zone problems, which we believe are amenable to varying degrees of cost-benefit analyses, are considered in considerably less detail in Appendices A, B, and C.

In Appendix A the possibilities for expanding the recreational use of **a** beach in a coastal community south of Boston are examined, while Appendices B and C examine nonrecreational uses of the coastal area. The particular cases chosen are: 1) an analysis of the benefits and costs associated with a shoreline location for a nuclear reactor power plant now under construction near Plymouth, Massachusetts, and 2) an examination of the costs and benefits associated with various strategies that might be followed for handling the oil demands of New England.

Once again these examples are provided not for the purpose of arriving at definitive recommendations related to the specific projects, but to illustrate methods for approaching complex public investment problems.

The general layout of Boston Harbor is shown in Figure 3.1. This body of water comprises about 47 square miles in surface area, containing thirty islands. These islands have a combined area of 1152 acres. Almost all this land is within six miles of the central business district of Boston and the bulk of it is within three miles.(22)

Despite this proximity and the islands' scenic attractiveness, this land has never served the major metropolitan needs of the region. The community's practice, rather, has been to use the islands, if at all, to remove various types of social unpleasantnesses from the mainland. Deer Island is used for a prison and a waste disposal plant. Long Island houses a hospital for the chronically ill. Spectacle Island houses a smoldering dump. With a few exceptions, the rest of the islands have been unutilized, since the decommissioning

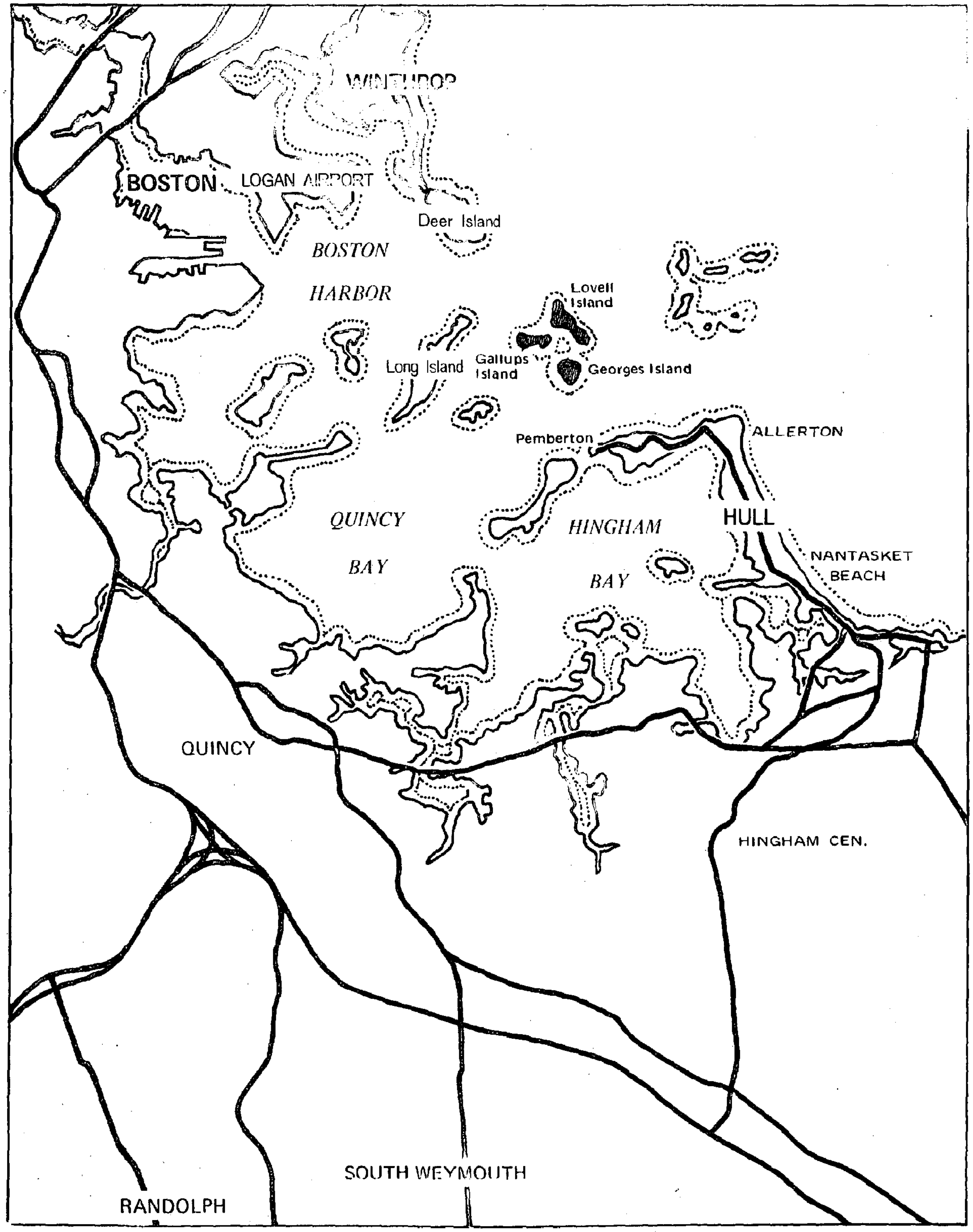

FIGURE 3.1 THE BOSTON HARBOR AREA

of the harbor forts.*

The rising demand on space in the Boston area plus the fact that, for a variety of historical reasons, much of the harbor land is in the hands of various public agencies has generated a number of proposals for development of the islands. These include acquisition of all the harbor islands and their dedication to recreation and conservation, construction of a model city in combination with a World's Fair, development of a jetport on the outer islands, filling and industrial development, and use of portions of the harbor for educational facilities. Since we are going to study only one of the myriad possible uses of one of the thirty harbor islands, the results or our analyses are at best provisional. We will be able to make a statement whether such a development is better than leaving Lovell as it is. However, we will not be able to determine whether this is the best of all possible uses of this island. In order to do this, it would be necessary to similarly analyze a representative spectrum of the other possible ways of employing this resource, such as housing, port facilities, et cetera. However, this limited analysis will serve our basic purpose of indicating some of the practical problems with respect to cost-benefit analysis.

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*This is not to imply that the harbor itself is unutilized. Approximately twenty million tons of cargo, 80% of which is petroleum products, are handled through the harbor annually. The harbor serves as the terminus of the Metropolitan District Commission sewage system. This system, serving over two million people, discharges four hundred and sixty million gallons of partially treated sewage daily into the harbor from the combined sewer system. Building wastes are burned just outside the harbor on barges. Much of the airspace and a large portion of the northern part of the harbor is used by Logan Airport implying, among other things, that a good deal of the harbor is subject to intermittent intervals of high noise levels. Development along the mainland shores is quite dense, although much of this development takes no advantage of the shoreside location. The harbor is utilized by some 11,000 bathers on a summer weekend day and is the home of at least 5,000 pleasure boats. The harbor at one time was an important source of fish and shellfish, but currently less than 1% of the fish landed at Boston are taken from the harbor and less than 10,000 bushels of shellfish are taken annually (23). Half of the harbor's shellfish grounds have been closed and shellfish from half the remainder have to be treated before they can be sold. Under the prevailing winds, the harbor's atmosphere is generally used first by the region's transportation, heating, and power generation systems.

THE OUTDOOR RECREATIONAL SITUATION AS IT RELATES TO THE HARBOR ISLANDS

Before proceeding to the analysis itself, it will be useful to review the general demand for water-related outdoor recreation in the Boston metropolitan region.

Despite New England's relatively cold weather and even colder waters, New Englanders presently lead the nation in per capita participation in water-related outdoor recreation. The 1965 National Survey of Outdoor Recreation conducted by the Bureau of Outdoor Recreation indicated that the average New Englander participated in .62 days of sailing in 1965 to .16 for the average American, 2.71 days of motor boating to 1.56, 3.11 days of ocean swimming to 1.58 (total all forms of swimming was: New Englander, 11.53; American, 6.84) and .75 days of waterskiing, to .42 for the country as a whole (24). Finally, the average New Englander enjoyed 3.05 days of fishing to 2.26 for the country as a whole (24). These differences reflect the availability of a long and unusually attractive shoreline, the average New Englander's better-than-average income, education, and high degree of urbanization plus perhaps a long heritage of communication with the sea.

These figures, of course, refer to the amount of demand for these forms of recreation actually realized, given the present supply of recreational facilities, the present transportation system, and present income and leisure-time distributions. Ideally for our purpose we need to know much more: the maximum amount people would pay for a particular recreational activity as a function of income, leisure time, quality of the recreation, et cetera, rather than a single point on this surface.

The National Survey also tabulates days' participation in each activity as a function of income from which we can obtain a preliminary estimate of the income elasticity of the demand for these sports. This data is shown in Table III.1 along with the corresponding arc elasticities. The average elasticity for each of the three sports for which sufficient data was available are all about .5, indicating that a 1% increase in income will tend to produce 1/2 % increase in per capita participation. Comparisons of the 1960 ORRRC figures (25) with the 1965 data indicate that rates of participation by income groups were relatively stable, perhaps because increased leisure was balanced by a drop in real earnings since the data is in current dollars, or perhaps because the supply of recreation decreased either in quality or ease of access.

There is one other piece of information we need before we can begin to construct the demand for outdoor recreation relevant to Boston Harbor and that is the split between recreation undertaken "away from Home"(on overnight or longer trips and that consumed at home (on trips of a day or less).

ORRRC #19 obtains the following percentages on the amount of recreation consumed on trips of a day or less versus that consumed "away" on overnight trips for each of the water-related sports (26).

	Home	Away
Boating	.46	.52
Waterskiing	.50	.50
Fishing	.38	.62
Camping	0	1.00
Swimming	.55	.45

That is, roughly half the water-related recreation is consumed on day trips. This is the market at which a recreational development in the Harbor would be aimed.

Dividing the New England participation rates on page 63 by two to reflect this split and using the Arthur D. Little projection of real income for New England we obtain the following projections of per capita participation rates in water-related, day trip, outdoor recreation for the next 30 years (27).

	1965	1980	2000
Ocean swimming	1.65	2.56	3.48
Power boating	1.35	2.10	2.84
Sailing	.3	.48	.65
Waterskiing	.38	.59	.61

This table assumes that the per capita supply of recreation remains unchanged. It is only one point on the demand curve. If the quantity and quality of recreation deteriorate or it becomes more expensive in real terms to enjoy this recreation, then the amount of recreational activity will, of course, decrease. If, on the other hand, more and better or cheaper recreational opportunities are supplied, then the participation rate will increase.

The harbor serves as the focal point for a region containing some two-and-one-half million people. According to the ADL projections, by 1980 the population of this area will increase to about 3.3 million in 1980 and 4.4 million in 2000 (28). Of course, this population is served by marine recreational facilities other than the harbor. The harbor is flanked on both the north and south by shoreline containing large attractive beaches, principally Lynn and Revere Beach on the north and Nantasket on the south. Further, other beach areas are within day-trip distance of the metropolitan region, including Duxbury, Plymouth, and western Cape Cod on the south, the Cape Ann beaches, Plum Island and Hampton Beach to the north. However, the first set of beaches, those within an hour's drive of the CBD are presently used to capacity on a summer weekend day and the latter set imply large travel costs for the one-and-a-half million residents of Boston Proper and the close-in cities of Cambridge, Brookline, Somerville, Malden and Everett. Therefore, it appears reasonable to assume that, if beach facilities comparable to those presently available could be supplied in the harbor at approximately the same total cost to the consumer, these facilities could expect to attract almost all the increase in demand for day trip ocean swimming arising in this close-in region. This increase amounts to 1.3 million swimmer days by 1980 and 4.2 million swimmer days by 2000, according to our projections.

The Massachusetts Outdoor Recreation Plan has made studies of the use of the Greater Boston beaches and concludes that, on the basis of a 90-day season, 2.2% of the use occurs on the average summer day.(29) Combining this with the above figures indicates that, given recreational qualities and access and use costs similar to those presently available, one could expect 30,000 bathers on a typical summer weekend day in 1980 and 90,000 in 2000. At the B.O.R.'s suggested standard of 75 square feet per person, this demand could be handled by two miles of beaches in 1980 and six miles in 2000.

THE AMOUNT PEOPLE ARE WILLING TO PAY FOR A DAY AT THE BEACH

The above section is a typical example of a classical, if very roughhewn, projection. One assumes that the supply situation will be similar to that existing at present; measures the present per capital consumption by income group; obtains estimates of future population broken down by income distribution and, in more extensive studies, by education, leisure time, vocation, etc.; and applies the present consumption rates to these figures. Such analysis is useful for obtaining a feel for the magnitude of the demand, but it can hardly be called a determination of the demand, which determination involves how people will react in a number of supply situations. The purpose of this section is to review the present state of the art with respect to determination of the demand curves for recreation and, in particular, the determination of how much people are willing to pay for a day of outdoor recreation.

Three methods for measuring the amount people would be willing to pay for outdoor recreation have been suggested in the literature.

The earliest is that by Hotelling who assumes that all people value a visit to a particular recreation spot the same (30). One then discovers (by, say, license plate survey) the total cost (time and travel) to the visitor who travels the farthest. Presumably he is the marginal user and the sum of the differences between the cost and the travel costs of each of the other visitors is the net benefit of this activity.

The difficulty here is that all people will not be willing to pay the same amount for a visit to the spot and, more importantly, one can be sure that the traveler who pays the most for a visit will have a far-above-average value. Nonetheless, the idea is not completely without merit. For example, one could determine the origins of the distribution of travelers, pick some intermediate, "representative" trip cost and assume it is the marginal one, ignoring all those travelers who have a higher trip cost and assuming that all those having lower costs place the same value on the visit as the arbitrarily chosen marginal traveler. This would at least lead to a consistent comparator of the attractiveness of alternate recreation spots.

For example, in the summer of 1965 the Metropolitan Area Planning Council (MAPC) conducted a 5,000 plate license survey of five major beaches in the metropolitan Boston area (31). At present we do not have the actual data, but the MAPC reports the following frequency distribution of trip times for these cars.

PERCENT CARS AS A FUNCTION OF TRAVEL TIME
DRIVING TIME IN MINUTES

	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80
Nantasket	6	11	14	19	23	13	11	3
Wollaston	41	30	16	8	4	-	-	-
Carson-Pleasure	11	37	21	8	2	1	-	-
Revere	24	30	22	11	8	3	1	1
Lynn	1	20	49	20	4	4	3	1

It is the absolute number, not percentages, that we need for the Hotelling analysis, but, for now, assume we rank the beaches according to the percentage of trips over 40 minutes.

Nantasket	50%
Revere	13%
Lynn	10%
Wollaston	5%
Carson-Pleasure	4%

With the possible interchange of Lynn and Revere (Lynn has severe parking problems), this is a ranking which the authors believe would receive a lot of support from beach-goers familiar with all five. In sum, a modified Hotelling procedure could prove useful.

The second method is that suggested by Clawson-Knetsch (32). This also starts from travel cost data. Suppose there are three population centers which visit a particular beach, A, B, C, as follows:

Pop.	Travel cost of Visit	Visit observed	Visits/1000
A 10,000	$3	10,000	10
B 20,000	$4	10,000	5
C 10,000	$5	2,500	2.5
		22,500	

No one having a cost of $6 is observed to use this beach. Plot participation rate versus cost as shown in Figure 3.2.

Now we want to know what the demand would be if we raise the cost x dollars. x = 0 we already know, 22,500. But if x = 1, the observed cost for A would be 4; for B, 5; for C, 6. The resulting participation rates would be 5,2.5, and 0, respectively, and the total demand realized would be 5 x 10 + 2.5 x 20 + 0 x 10 = 10,000. This assumes each group reacts to price in the same manner. Continuing in this manner for increasing x, we obtain the demand curve shown in Figure 3.3. Knetsch interprets the area under this curve to be the consumers' surplus or net benefit of the activity. This assumes not only that each group has the same value on visits (which is much less restrictive than the Hotelling assumption of equality of values for each person as before), but also that the consumers' surplus for everybody at x = 0 is zero, which is certainly conservative and, in fact, a lower bound. Thus, by combining both the Clawson Knetsch method and the Hotelling method, we can bound the aggregate value of the activity. It might not be unreasonable to base investment decisions on the average of the two. Or, if one were willing to assume that the demand curve was convex, this average would form a new upper bound. Anyway, values obtained by both methods would be of interest. Knetsch notes that the assumption that each cost group places the same value on the visit can be relaxed considerably by dividing the visitor population

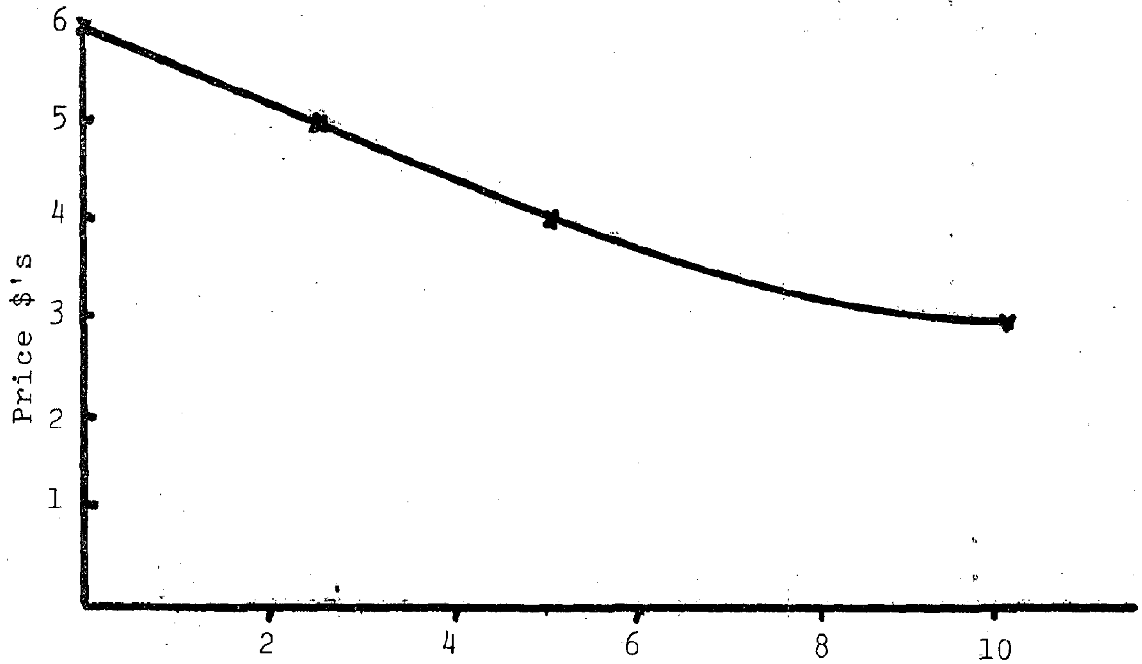

FIG 3.2 Participation Rate (Visits Per Thousand Population)

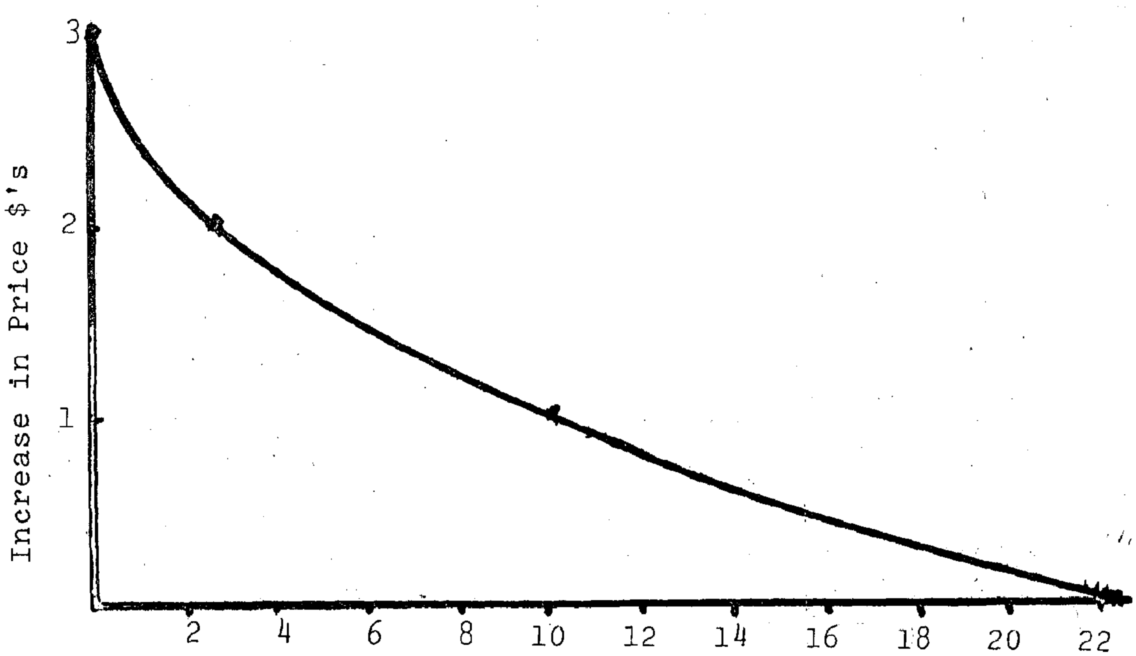

FIG.3.3 Demand In Thousands of Visits

not only by travel costs, but also by income and other socioeconomic characteristics and then making the standard assumption that each subpopulation places the same value on the visit. This observation applies equally well to the Hotelling method and thus, through it, we could obtain increasingly narrower bounds on the aggregate value at considerable expense in data collection and reduction.*

Mack and Myers express considerable doubt as to the possibility of determining the aggregate value of a recreation activity and suggest rather the concept of merit-weighted users' days (33). This latter is a distributional measure which has no relation to individual values as used in this report. As such, it is useful only in choosing between alternate recreation investments of about the same social cost. The merit refers to a means for consistently implementing distributional judgments rather than to the quality of the recreation. However, they do discuss in some detail dollar values derived by combining national data on total dollar expenditures on outdoor recreation with the total hours spent in outdoor recreation in several ways. All these calculations lead to the fact that, in 1960, people spent an average of approximately $2.50/day (1960 dollars) on outdoor recreation. Obviously, on the average, the value they placed on this recreation must have been higher. Thus, this figure serves as a quickly-arrived-at lower bound on the average amount people are willing to pay for recreation. It would be useful to subdivide the aggregate data by type of outdoor recreation and by socioeconomic characteristics of the population in the same manner as above to derive lower bound on the average amount each subpopulation is willing to pay for each activity. Joint activities would undoubtedly cause difficult problems with this approach.

We have followed up none of these approaches. Rather consistent with our comments in Chapter II we will calculate the net present value gross benefits of our recreational facility for a range of user values, leaving to the political process the final comparison. However, we hope that the above discussion indicates that with some thought and ingenuity it should be possible to at least estimate the amount that various population groups would be willing to pay for a recreational experience.

INCREASE IN REAL BENEFITS WITH TIME

Given that we have chosen a particular individual user benefit for a day at the beach, say, $2.50 1960 dollars, we will need a means of escalating this value through the next 40 years to reflect the projected increase in the <u>real</u> amounts that people are willing to

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*The fineness of such subdivision would be limited by available data.

pay for a particular recreation activity as a result of increases in real income ,further urbanization, more leisure time, et cetera. For our purposes, we will base our projected increase solely on income.

Clawson and Knetsch in reference (34) indicate that the percentage of disposable income spent on outdoor recreation has been rising irregularly at an average rate of .1% per decade over the last 25 years. It is presently about .7%. In view of this data, it would certainly be conservative to assume that the demand for recreation will increase only proportionately with real income. Toi has extrapolated this to predict that, by the year 2000, people will be spending 2% of their disposable income on outdoor recreation (35).

Kahn and Wiener predict that the real per capita income will rise according to the following schedule through the next 40 years (36);

1965	1971	1975	1985	2000	2020
1.00	1.16	1.26	1.65	2.56	4.40

and* these are the figures we will use in escalating the base gross per capita benefit in the following analyses.

THE COSTS OF A PARTICULAR RECREATIONAL DEVELOPMENT IN THE OUTER HARBOR

As noted earlier, we are not going to attempt to analyze all possible recreational developments of the Boston Harbor islands. Rather, we are going to postulate a particular development and apply cost-benefit analysis to the single alternative. The particular alternative we have in mind concerns Lovell Island, well out in the

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*This fact together with our earlier observation that days' participation increases only half as fast as income indicates that as income increases the increased expenditure is spent equally on more recreation and on increased quality of recreation.

harbor. Lovell contains some 56 acres and has about 4,000 feet of shoreline facing the ocean. At present, there are no beaches on Lovell, but the ocean side consists of tidal flats on which we postulate filling and protection to provide 25 acres of beach. The littoral drift along this coast is southward. Therefore, we postulate a large groin projecting from the island's southern end with a triangular fill in the corner formed by the groin and the island. There are no beachs or even any shoreline downstream from the groin so there are no downstream areas which are likely to be affected by the groin. We also hypothesize the provision of picnic grounds and open areas for picnic-related sports on the island proper. We postulate sanitary facilities, a transportation system, and sanitary facilities such that, at peak density, the development will be operating at 75 square feet of beach per person and 130 persons per acre. These are the standards recommended by the Massachusetts Outdoor Recreation Plan. It should be noted that they are considerably more generous than the standards at peak use of the present urban beaches. Thus, we are considering a relatively high quality of recreation. Given these standards, our proposed development can accommodate about 14,000 people. Comparing this figure with the estimated projections of excess demand for urban beach recreation, we note that even at peak operating capacity this facility will not come close to saturating the market. The purpose of this section is to estimate the value of the resources which will have to be employed to develop and use this recreational facility. These costs can be divided into four categories:

The opportunity cost of the land;
The cost of providing and maintaining the physical facilities;
The cost of providing access from the mainland;
The cost of getting to the mainland terminus of the mainland-to-island link.

THE OPPORTUNITY COST OF THE LAND

This land is already in the hands of the Metropolitan District Commission. Hence, its employment as a recreational facility by the public involves no financial costs to the public. This does not imply that the land is a free resource for, if the community opts to develop this land as a recreational facility, it cannot use the land in some other use, and the cost of this employment is the value of the land in its most valuable alternative use. Given that there is no convenient access, it appears that the opportunity cost of the land is quite low. However, given that we provide access to the island, as we intend to, then the land may have substantial value for, say, a high-rise residential development. However, without simultaneously analyzing these other alternatives, we cannot say what this value is. Therefore, we are going to take the opportunity cost of the land to be zero, its approximate value in its present use, with the caveat that such an assumption limits us to comparisons between the present use and the use which we are analyzing. Actually, if one analyzes all possible alternatives using the assumption that the land had an opportunity cost of zero, the resulting rankings would be correct as long as one uses the maximum net present value criteria. This is not necessarily true if one uses maximum benefit/cost ratio.

FILLING AND BEACH PROTECTION

With respect to provision and protection of the beach and provision of physical facilities on the island, market costs offer a reasonably reliable indicator of true costs to the community. The market cost may overstate the opportunity cost due to monopolistic positions in certain portions of the labor market; however, this is unlikely to be significant.

The mean tide in Boston is about nine feet. In order to develop twenty-five acres of beach from the present tidal flats will require about 500,000 cubic yards of fill. The present market cost of fill in place in Boston Harbor is about $2.00 per cubic yard. In addition, we will require a large groin, about 250 yards long, at the southern end of the beach. In the absence of more detailed costing, we will estimate the costs of the construction of this groin at 50% the cost of the fill. Thus, the initial costs associated with provision of the beach is $1,500,000. We will assume that we will lose 10% of the fill per year and thus the cost of maintaining the beach is estimated to be $100,000 annually. The present value of this stream of costs for 40 years at 5% is $3,400,000. In an actual analysis, the design of the beach and its protection and the expected loss per year should be the subject of intensive hydrologic studies on which these costs would depend.

COST OF PHYSICAL FACILITIES

Analysis of facilities at present beaches in the area indicates that it requires about 1.6 square feet of bathhouses and rest rooms to support a bather. We will assume that any food stands or snack bars are run on a self-supporting basis and that the users figure that the marginal value of the items purchased is equal to the resulting price. Hence, we need not consider these facilities within our calculus. Thus, for our purposes we will require about 22,000 square feet of test rooms and bathhouses. We also intend to provide picnic facilities at a density of 12 locations per acre or 600 picnic sites. We estimate the cost of the covered facilities at $24 per square foot and the cost of the picnic sites at $1500 apiece where costs are taken to include paths, landscaping, fireplaces, and open shelters capable of handling 25 people apiece (37). The costs of lighting and electrical distribution are taken to be $500 per acre (38). In summary, our rough estimates of the initial and annual costs of the physical facilities are:

	Initial	Annual (Estimated)
Rest rooms, bathhouses	$ 530,000	$ 50,000
Picnic sites, landscaping, shelters	900,000	50,000
Lighting	25,000	5,000
	1,455,000	105,000
Present value of cost for 40 years at 5%	$3,495,000	

MAINLAND TO ISLAND TRANSPORTATION SUBSYSTEM

The costs of providing access to the facility are properly imputed to its use. Once again the costs that we are interested in are the marginal costs associated with the facility. If a presently available resource can be utilized in providing this transportation, it is the additional costs associated with this use that we are offered. The past construction costs, etc., are irrelevant to our analysis.

In this section we consider the costs of providing transportation from the mainland to the island. In the following section, we will consider the costs of transportation from the home to the mainland terminus of the island transportation system.

For our purposes, we will postulate the following design criteria for the mainland-to-island transportation system: this system shall be capable of transporting 14,000 people from the Boston waterfront to Lovell in four and a half hours in the morning and returning them in the same amount of time in the afternoon. In an actual analysis, the determination of these criteria would in itself be the subject of a subsidiary cost-benefit analysis, for the demand will depend in part on the level of service offered. For now, we will accept this particular level of service.

In order to perform this function, we have analyzed two possible ferries.

TABLE III.2

Typical Ferry Boat Data (39)

	Dimensions length-beam-draft-	Displacement tons	Speed knots	Passgr No.	First cost $1000	Daily dir. opert. cost $	Crew No.
1	50x12x5	57	12	100	100	200	3
2	100x20x7	260	12	600	460	600	10

The one-way distance from Rowes Wharf in downtown Boston to Lovell is six nautical miles. Allowing ten minutes at each end of the trip to load and unload, the round-trip time for each of these vessels would be 70 minutes. In four and one-half hours, each vessel could make four trips. Thus, our criteria would require 35 of the 100 passenger vessels and six of the 600 passenger ferries. The economies of the large ship are obvious; therefore, we will consider only this design in the sequel. Of course, in an actual study a complete parametric analysis of all possible vessels, including hydrofoil and ground effect machines should be undertaken to determine the minimum cost system capable of performing the selected function. Such substudies would feed back on the selection of the level of service criteria as it became clear what each level of service would cost.

Given that we employ vessel #2 and we assume this ship has a useful life of 20 years, we will have the following set of costs:

INITIAL COSTS

Six ferries	$2,750,000
Slip and jetty at Lovell	60,000

(Opportunity cost of using Rowes Wharf is essentially zero.)

ANNUAL COSTS

100 days' operating costs	360,000
Annual maintenance at $50,000 per ship	300,000

TWENTIETH YEAR COSTS

Six ferries	$2,750,000

Discounting at five percent over 40 years, this cost stream has a present value of 16.5 million dollars. If we assumed the facility is used at capacity 25 days per year and at 50% capacity for 75 days, these costs could be recovered by a user charge of $1.00 for the round trip.*

THE COST OF TRANSPORTATION FROM HOME TO ROWES WHARF

The marginal costs of the home-to-Rowes-Wharf trip and return are also part of the cost associated with using this facility. We will assume that, since this is a recreational trip, the consumer values the time in transit neutrally. That is, on the average he would neither be willing to pay anything to shorten this time nor would he be willing to pay anything to obtain any benefits, such as sightseeing, from this portion of the trip. There is considerable evidence that on business trips commuters value their time from anywhere in the neighborhood of $1.55 per hour to, in some cases, $10.00 per hour (40). Therefore, the assumption of no net value of travel time is undoubtedly biased in favor of the project. However, with this assumption we will be able to concentrate on the money costs of the trip to the mainland terminus of the island transportation system. These costs can be grouped into two categories:

1) The social cost of the transportation resources used in making the trip;

2) If a car is used, the costs of storing a car downtown while on the island.

These social costs will vary considerably, depending upon whether we are talking about a weekend or a middle-of-the-week day. In order to obtain a first cut at these costs we will make the following assumptions:

a) As before, the facility is used by 14,000 people on 25 weekend days and by 7,000 people on 75 middle-of-the-week days.

b) On the weekdays, three-fourths of the people travel to Rowes Wharf by the present mass transit system and one-fourth by car at four people per car. The average one-way trip length of the former is five miles and of the latter ten miles.

c) On the weekend days half of the people travel to Rowes Wharf by car at three people per car. The average trip length of this trip is 12 miles. The other half travel ay mass transit at an average trip length of six miles.

* 875,000 users per year. Charges collected at time of use and discounted accordingly.

In a real study, of course, substudies would be required to predict trip length and trip modes.

The relevant costs are the marginal costs associated with this particular trip. On the weekdays, the marginal cost associated with the off-peak mass transportation users will be quite small, in many cases zero, given that the operation of the transit system is not a function of this particular type of trip. On the other hand, those recreationists who use the system during the rush hour will impose congestion costs on all other peak users. As a first approximation, we have decided to balance these by assuming that the average marginal cost is equal to the present fare which currently is about 20% less than the average cost per user of operating the mass transit system. With respect to weekday car trippers, we will estimate their marginal costs at three cents per mile (approximately fuel and oil. We are tacitly assuming no car purchase decision is based on this potential trip) and the storage costs at $3.00 per day (the current market rate of parking downtown), for the parking system is currently fully utilized during the week and operates in a reasonably competitive market. Thus, the decision of our car user to take his car implies that someone else cannot use this space.

On the weekend, the mass transit users will impose no congestion costs on the rest of the community. However, it is quite likely that some additional service will have to be scheduled to serve this demand with resultant differentials in the transit system labor costs. Therefore, despite the fact that the system as a whole is underutilized on the weekends, the marginal costs are not zero. Once again, as a first approximation, we will assume them equal to the fare. This is probably an overestimation. With respect to the car users, once again we will estimate the marginal cost of the trip at three cents per mile. However, downtown parking lots are rather severely underutilized on a summer weekend day. Hence, the opportunity costs of their use by the island users will be quite small, probably amounting to no more than the hiring of several parking lot attendants for weekend duty. As a first approximation, we will value this cost at zero.

Thus, the downtown parking case is a classic example of a situation where the same use, the storage of a car for a day, can impose very different demands on the economy, depending on differences in competing demands. Note that at present the private market does not reflect this difference. There is little difference in weekend and weekday parking rates in downtown Boston, even outside the central retail district.

Given all these assumptions, we have the following estimate of the shoreside costs in constant value dollars:

is used at capacity 25 days per year and at 50% capacity for 75 days, these costs could be recovered by a user charge of $1.00 for the round trip.*

THE COST OF TRANSPORTATION FROM HOME TO ROWES WHARF

The marginal costs of the home-to-Rowes-Wharf trip and return are also part of the cost associated with using this facility. We will assume that, since this is a recreational trip, the consumer values the time in transit neutrally. That is, on the average he would neither be willing to pay anything to shorten this time nor would he be willing to pay anything to obtain any benefits, such as sightseeing, from this portion of the trip. There is considerable evidence that on business trips commuters value their time from anywhere in the neighborhood of $1.55 per hour to, in some cases, $10.00 per hour (40). Therefore, the assumption of no net value of travel time is undoubtedly biased in favor of the project. However, with this assumption we will be able to concentrate on the money costs of the trip to the mainland terminus of the island transportation system. These costs can be grouped into two categories:

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Thus, the downtown parking case is a classic example of a situation where the same use, the storage of a car for a day, can impose very different demands on the economy, depending on differences in competing demands. Note that at present the private market does not reflect this difference. There is little difference in weekend and weekday parking rates in downtown Boston, even outside the central retail district.

Given all these assumptions, we have the following estimate of the shoreside costs in constant value dollars:

Annual number of mass transit users = 33,000	
Annual cost of mass transit use @ 50¢ round-trip fare	= $284,000
Annual number of weekday care = 33,000	
Annual cost of weekday car trips @ 360¢	= 119,000
Annual number of weekend cars = 58,500	
Annual cost of weekend car trips 2 @ 72¢	= 42,000
Total Annual Cost	= 445,000
Present value of shoreside transportation costs @ 5% for 40 years	= $7,740,000

SUMMARY OF COSTS

Beach filling and protection	$ 3,400,000
Physical facilities	3,495,000
Island transportation	16,500,000
Shoreside transportation	7,740,000
Total	$31,100,000

INTERIM SUMMARY

We have estimated that the present value of the costs of providing and utilizing the postulated recreational activity on Lovell Island for the next 40 years to be $31,100,000 1970 dollars. If this figure is correct, it implies that, in order for the provision of this facility to be a more economic use of the island than its present use, the consumers of this recreation will have to value the benefits of a day at the island, including the trip, at $1.80 per visit or more. If the average visitor values the trip to this island and his stay there at more than $1.80, then the postulated recreational investment should be built rather than leaving the island as it is. If the average visitor values the trip and stay at less than this value, the resources needed to provide this recreation are more highly valued by society in other uses.

The $1.80 figure assumes the consumer places the same real (1970 dollars) value on a trip in 1970 as he does on a trip in 2010. We have suggested earlier that the real amount that the people would be willing to pay for recreation can be expected to rise proportionally with increases in real income. If this is the case, and using the income projections on page 70 , then, if people are presently willing to pay $1.30 for a trip and visit, this value will escalate through time in such a way that the net present value of the project is zero. That is, we would be indifferent between the postulated development and leaving the island as it is.

As noted earlier, given the present state of the art, it is impossible to say how much people value (are willing to pay for) the recreation that the postulated facility would provide. We saw earlier that Mack and Myers indicate that it might be in the order of $2.50 per visit, in which case this project is definitely more economic than leaving the island as it is, accepting for the moment all our assumptions about cost and utilization. In any event, in cases like these where the benefits cannot usefully be estimated, it is extremely useful for the decision-maker to have available the net present value as a function of a number of assumptions about the magnitude of the benefits to be obtained from a public investment. In such a situation, which is the typical case, the analyst can no longer recommend that alternative which is most consistent with the community's values, but rather is reduced to pointing out which alternatives are consistent with what assumptions about these values, ruling out those alternatives which are dominated--not consistent with any reasonable set of values. The community or its representatives will have to explicitly make the value judgments required to determine the final choice. With this information in hand, the community or its representatives is generally in a much better position to make a judgment concerning the remaining alternatives, and much less likely to choose alternatives that are inconsistent with its own values, the system analyst's definition of tragedy.

A very simplified example of the display of the type of information we are talking about is shown below.

TABLE III.3

Gross Benefit per Visit (no escalation)	Net Present Value 40 Years @ 5%
1.00	$- 14.3 \times 10^6$
1.50	$- 5.8 \times 10^6$
2.00	$+ 2.6 \times 10^6$
2.50	$+ 11.1 \times 10^6$
3.00	$+ 19.5 \times 10^6$
3.50	$+ 26.8 \times 10^6$
4.00	$+ 36.3 \times 10^6$

(Escalation with real income according to page 70)

1970	2010	
1.00	2.90	$- 7.0 \times 10^6$
1.50	4.35	$+ 5.2 \times 10^6$
2.00	5.80	$+ 17.2 \times 10^6$
2.50	7.25	$+ 29.5 \times 10^6$
3.00	8.70	$+ 42.8 \times 10^6$

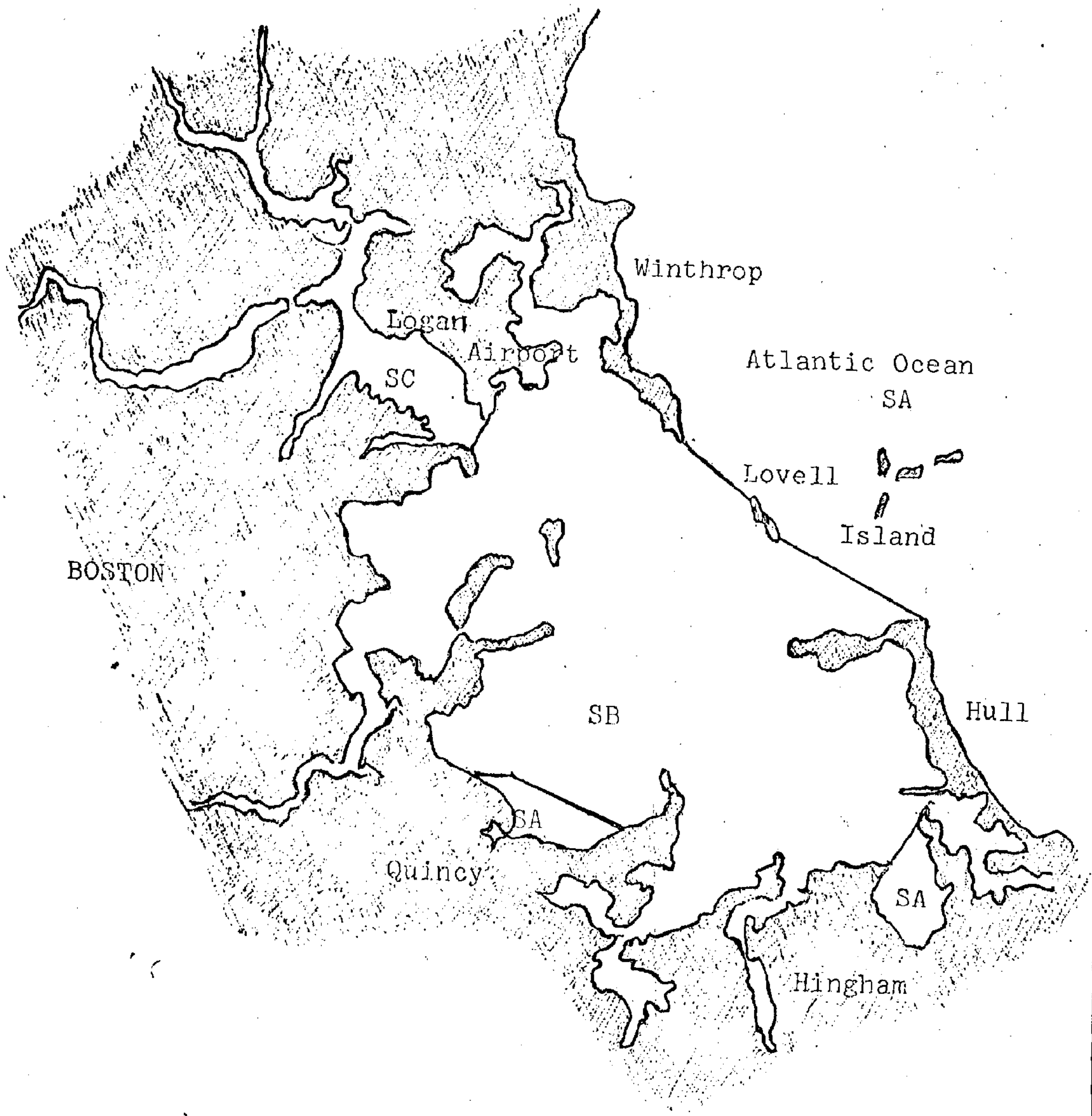
INTRODUCTION OF UNCERTAINTY INTO THIS PROBLEM

There are a great many areas of uncertainty related to this problem. There are uncertainties with respect to costs. We have just indicated the uncertainty with respect to demand. However, many of the former set of uncertainties can be dispelled by more careful cost analysis; therefore, we have not chosen to apply probabilistic methods in this area. We could have attempted to extract the community's subjective distribution on the present and future values of the amount people are willing to pay for the recreation and then shown whether the development was consistent with this distribution. However, given the problems associated with communal probability distributions, this is not usually a useful exercise and we have chosen to present the decision-maker with the results of assuming different demand values for a number of these values. Rather, we have chosen for our present expository purposes to apply uncertainty to an entirely different area, that of water quality at the facility.

The value or benefits associated with a recreational beach in the mouth of Boston Harbor during the next 40 years will be critically dependent on the quality of water at this beach through this time period. At present, the water quality in Boston Harbor ranges from anerobic cesspool to marginally suitable for bathing. Figure 3.4 indicates the present federal classification of the harbor. These ratings are probably generous. The beaches in Winthrop have been closed to bathing for some years and the South Boston beaches are closed periodically. As well be seen, the SB line (water suitable for bathing but restricted to shellfishing) extends along the inshore coast of Lovell Island. However, much of the waters rated SB on this chart is shunned by swimmers and periodically very high coliform counts in these areas bear out their judgment. In short, at present the waters in the proposed beach area are suitable for swimming almost all the time. However, they cannot be called clean and further deterioration would materially affect the quality of the swimming. Thus, in investing in a 40-year or greater lifetime system, the community must carefully consider what the water in the areas will be like during this period.

Of course, the water quality in the harbor is a variable which is under the community's control. Let us postulate three alternative developments:

a) The region decides to make a concerted effort to improve the water quality in the harbor through such means as construction of a deep rock tunnel carrying all combined sewer effluent to deep water, as suggested by Camp, Dresser and McKee, at a $2,000,000,000 initial cost (41). As a result, the water quality in the vicinity of Lovell is such that it in no way limits the use of the area as a beach.



BOSTON HARBOR
Water Quality Classification

FIGURE 3.4

Commonwealth of Massachusetts
Water Resources Commission

b) The region decides not to decrease the water quality in the harbor further. Collectors for part of the combined sewer outfalls are constructed and portions of this effluent given primary treatment. Increased demand from population growth is handled through outlets other than the harbor. As a result, the water quality at Lovell stays where it is--usable for bathing but intermittently embarrassing and not comparable to the Cape or the beaches well outside the harbor.

c) The region opts to use the harbor more intensively for sewage disposal. All the growth in demand in the metropolitan district is handled through the harbor. There is no upgrading of the combined sewer system which periodically discharges large quantities of raw waste into the harbor. As a result, in ten years' time, the beach at Lovell is closed to bathing.

Given these three hypothetical possibilities, how do we include them in our analysis?

Even though the future water quality in the harbor is under the region's control, from the point of view of making the decision as to the investment at Lovell today the future water quality cannot be predicted with certainty. It is a random variable or, more properly, a random process, since we are dealing with a random variable through time.* The problem then is to estimate the probability that at any time in the next 40 years the value of the water quality at Lovell will be such and such. With such probabilities and knowledge of the change in benefit values with water quality, we can straightforwardly, if tediously, apply the expected value analysis outlined in Chapter 2. For our purposes here, we will arbitrarily simplify the situation in order to point out how this might be done.

We will assume that only three of the myriad possible time histories of water quality through the next 40 years at Lovell have probabilities high enough to deserve analysis. These three trajectories are shown in Figure 3.5 . Further, we will assume that, if the water quality at Lovell is SA, then a visit to the island is worth 25% more to the bather than if it is SB. If the water quality is SB, then the values predicated in the earlier analysis under certainty hold. If the water quality is SC, then the beach is closed

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*This example points out an important difference between our use of the term "random variable" and the classical statistician's. The future water quality in the harbor is not random variable to the statistician, since he cannot hypothesize a series of experiments whose statistics would reveal the value of this variable. For us, anything whose value we do not know with certainty is a random variable.

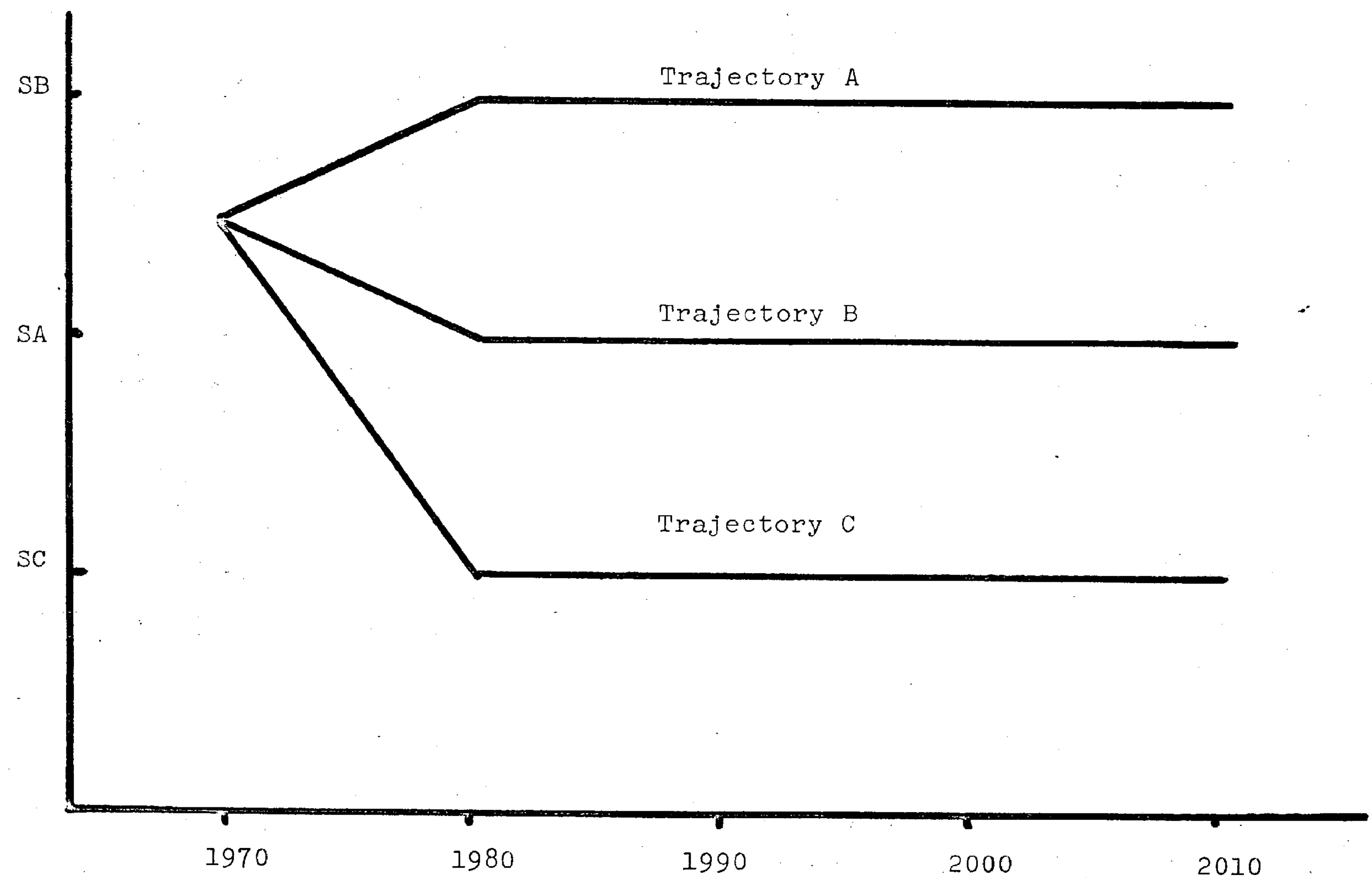

FIGURE 3.5 Three Hypothetical Time Histories of Water Quality at Lovell Island

and the investment in the island is scrapped, at negligible scrap value. Table III.4 is an expansion of Table III.3 and indicates the net present value for each of these eventualities under a range of assumptions about the original value of the recreational activity to the swimmer.*

TableIII.4 begins to illustrate the basic problem involved in leaving valuations up to the decision-maker(s). It doesn't take very many such valuations before, in combination, they lead to a very large number of alternatives and the analyst's report becomes no more than a confusing welter of figures. The analyst must, therefore, impute valuations wherever he can reasonably do so, making clear to the the decision-maker(s) under what assumptions such valuations have been made, leaving the decision-maker(s) the responsibility of making only one or two of the most intractable and critical judgments.

In the case at hand, if the society is an expected value decision-maker and is willing to assign subjective probabilities to each of the three postulated time histories of water quality we can once again collapse Table III.4. This author, by asking himself questions of the sort: At what probability, x,would be indifferent between a lottery ticket yielding him $1000 with probability x and a lottery ticket yielding him $1000 if time history A occurs and repeating the process for time histories B and C determined that <u>his</u> probability distribution of the three alternatives is:

Pr(A)=.05
Pr(B)+.50
Pr(C)=.45

* One of the objections that one sometimes hears to the above type of analysis is that generating such figures is useless since the figures depend on assumptions; change the assumptions and you change the figures. But the very point that we are trying to make is that the figures make clear which alternatives are consistent with which assumptions. They had better change with change in assumptions. Of course, sometimes people object to being faced with the consequences of their assumptions. Alexander calls this a "loss of innocence":

> " The use of logical structures to represent design problems has an important consequence. It brings with it the loss of innocence. A logical picture is easier to criticize than a vague one since <u>the assumptions it is based on are brought out in the open</u>. (emphasis ours)...I wish to state my belief in this loss of innocence very clearly because there are many designers who are apparently not willing to accept the loss. They insist that design must be a purely intuitive process; that it is hopeless to try and understand it sensibly because its problems are too deep." (42)

Alexander is talking about architects and urban designers. But the same point applys to humans in general and polititians in particular.

TABLE III.4 NET PRESENT VALUE OF LOVELL BEACH FACILITY UNDER THREE DIFFERENT WATER QUALITY TRAJECTORIES

NET PRESENT VALUE GIVEN TRAJECTORY A

INITIAL GROSS BENEFIT PER INDIVIDUAL TRIP (no escalation with income)	NET PRESENT VALUE 40 YEARS @ 5% (Millions of 1970 dollars)
$1.00	-12.3
1.50	- 2.3
2.00	+ 7.2
2.50	+16.9
3.00	+26.4
(escalation with real income per page 69)	
$1.00	+ 1.5
1.50	+17.7
2.00	+33.9
2.50	+50.3
3.00	+66.4

NET PRESENT VALUE UNDER TRAJECTORY B
(same as Table)

(no escalation with income)	
$1.00	-14.3
1.50	- 5.8
2.00	+ 2.6
2.50	+11.1
3.00	+19.5
(escalation with real income)	
$1.00	- 7.0
1.50	+ 5.2
2.00	+17.2
2.50	+29.5
3.00	+42.8

NET PRESENT VALUE UNDER TRAJECTORY C

In this case, no costs are incurred after the tenth year. The present value of the truncated cost stream is $16.2 million dollars)

(no escalation with income)	
$1.00	- 9.3
1.50	- 5.8
2.00	- 2.4
2.50	+ 1.1
3.00	+ 4.2
(escalation with income)	
$1.00	- 8.5
1.50	- 4.7
2.00	- .8
2.50	+ 3.0
3.00	+ 7.8

Let us for the moment assume that the author is an expert in the water quality of Boston Harbor, which he isn't, and that the analyst is willing to accept this distribution as descriptive of the community's distribution on this random variable or, better yet, the relevant decision-maker(s) are willing to accept this distribution as descriptive of the community's distribution, then, as outlined in Chapter II, Table III.4, collapses to:*

TABLE III.5 EXPECTED NET PRESENT VALUE OF LOVELL BEACH FACILITY ASSUMING PROBABILITIES OF WATER QUALITY TRAJECTORIES A,B, AND C ARE .05, .50, and .45, RESPECTIVELY

INITIAL GROSS BENEFIT PER VISIT	EXPECTED NET PRESENT VALUE 40 YEARS @ 5% (millions of 1970 dollars)
(no escalation)	
$1.00	-12.5
1.50	- 5.6
2.00	+ 2.7
2.50	+ 6.9
3.00	+15.2
(escalation with real income)	
$1.00	- 7.3
1.50	+ .6
2.00	+ 9.9
2.50	+18.0
3.00	+27.2

Thus, accepting our costs and other assumptions, if the community has these probabilities on water quality, the facility should be built rather than leave the island as it is, if the present average gross benefit (the maximum amount the average user is willing to pay for a visit) is greater than about $2.00 assuming no escalation, or greater than about $1.50, given escalation in proportion to projected increase in real income. ** Notice that since we have not evaluated any alternatives

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*In an actual study, this distribution might be determined by assembling a group of authorities on the subject, extracting the distribution of each, and letting them argue out differences in the distributions. From this point of view, subjective probability becomes a means of incorporating and weighing expert opinion in the cost-benefit analysis.

**It is important to recognize that we are not guaranteed the values shown in Table III.5. Let us assume that the community's present gross benefit is $2.00 and no escalation is assumed. Then the community should build the facility rather than leave the island as it is. This is the right decision; that is, the decision that is consistent with its assumed values other than the postulated beach facility and implicitly leaving the island as it is at zero net benefit, we cannot make any judgments about whether or not the beach facility is the best use of this island, only that in these cases it is better than leaving the island alone. A full-scale analysis of the island would include a representative spectrum of different alternative employments and mixes of these employments. For example, by postulating a high-rise residential development as well as a beach, we may be able to take advantage of substantial economies of scale with respect to the island-mainland transportation system, especially since the residential travel will generally flow in the opposite direction to the recreational flow.

In making comparisons of the present alternative with other possible developments, displays such as Table III.4 will be useful in comparing the beach facility with other developments which will be less sensitive to water quality, such as a pure high-rise residence or almost completely insensitive to water quality, such as an oil terminal.

FINANCING THE PROJECT

Let us assume for the moment that the community's decisionmaker(s) decide that the present gross benefit per visit is $2.00 and some escalation of this value is in order and that providing the beach and leaving the island as it is are the only two feasible alternatives, in which case our analysis indicates that, if the community is going to operate in a manner consistent with its values, the beach should be built. The question that immediately arises is who is going to pay for it and how? From whom are we going to transfer the resources required to implement this project? This question is explicitly distributional in nature and hence our complete concentration on economic efficiency in this report becomes more than a little bit uncomfortable at this point. However, if we are prepared to be indifferent to the haphazard and rather small scale transfers of income which can be

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** (continued) and the knowledge it has at the time of the decision. Given that it does so, it is quite possible that trajectory C will obtain, in which case the project loses money. This does not imply that the wrong decision was made. One of the most basic differences between decision-making under certainty and decision-making under uncertainty is that in the latter case one cannot judge the correctness of the decision by the outcome.

effected at the project level, efficiency has a number of important things to say about how the project should be financed.*

In fact, it is not possible to be consistent with our basic principles unless the user is charged at least the marginal social cost of his trip to Lovell. In this sense the provision of public projects and their financing cannot be separated. (43) Failure to charge the user the marginal cost of his trip will lead to Pareto-inefficient congestion, and public pressure for expanded facilities which would not be demanded at marginal costs--inefficient use of a project whose justification was economic efficiency.

Now a floor on the marginal social cost of an individual trip is the value of the added resources required by the marginal user which, as in the case above, can be quite small. If the beach is there and the ferries running and if there is room for an additional passenger and an additional beach blanket, the addition of one more beach user implies that the rest of society foregoes almost nothing. Therefore, it appears we are back in the now-familiar- decreasing costs bind--efficiency requires price equal to marginal cost and the revenues thus generated will not cover the total costs of the project. Financing remains a problem.

This is true. However, there are several ameliorating circumstances which point to user charges above the cost of the extra resources implied by the marginal trip.

1) In situations where alternate goods (say, an inland swimming pool) are charging above marginal costs, then one can argue for a charge above marginal cost to prevent over-utilization of the subject project at the expense of underutilization of the competitive project.(44)

* To the extent that the nation opts to perform any desired income redistribution through taxation at the national level, the easier it will be to be indifferent to income transfers at the project level--an important by-product of income redistribution at the national level.

2) The marginal costs the user should be charged should include not only the market costs implied by his use but any extra non-market costs such as pollution which result. This consideration is unlikely to be important in the case at hand but might be critical in the case of say, industrial use of a publicly provided navigation facility.

3) The fact that the difference between the total of the user charges and the total of the costs of the project will have to be made up by taxation which itself implies a distortion of the economy argues that user charges should be set somewhat above marginal costs. See reference(45).

4) Most importantly, in cases where the project is being used at or near capacity, the costs of the extra resources required by a marginal user are no measure of the social cost of the use for one person's use of the facility will be preventing or decreasing the value (through congestion) of someone elses use. The amount the other users actual and potential including the potential user shut out would be willing to pay to not have him use the facility is the social cost of this trip.* In short, the basic purpose of pricing is to ration out the existing facilities to those users who value it most highly (given the present income distribution). Efficiency requires that prices should be raised to the point where this rationing is effective. This can imply users charges which are much larger than even the average cost of the use.

* In accordance with our basic definition of social cost, this is an either-or situation. If the actual users are willing to pay more for one less person on the beach then potential users are willing to pay to take the place of the marginal user, then the actual users determine the social cost of the marginal users. Otherwise, the potential user's bid is the social cost. A case of the former possibility is evident at those ski resorts which charge a premium for limiting daily sales of lift tickets.

Shutting low income groups off from public projects just when the demand for these projects is at a peak may seem to be an awfully high price to pay for resource efficiency. However, as we shall see, application of these principles can be a two-edged sword working for as well as against low income groups. Consider the case of public project, like our proposed beach, which is subject to time-varying demands. The demand for the project on a weekend will in general be much higher than the demand on a weekday. Consequently, user charges should be higher-quite possibly much higher on weekends than on weekdays. One may find that on a weekend one has to charge $4.00 per person per day to prevent congestion while on a weekday one is forced to reduce the charge to 25¢ per head to fill the beach. Under the assumptions, made earlier, this combination of charges would make the project self-supporting. Furthermore, the consequences with respect to income distribution are obvious. The weekend user would be the middle income citizen whose job both forces him and allows him to pay the premium for weekend use. The week day user would be middle and lower income children who have the freedom to take advantage of the beach while their more fortunate brethren are working. In short, there are many situations in which efficient pricing of public goods will coincide with the most egalitarian tastes about income distribution.*

All the above notwithstanding, in many cases, efficiency will call for the provision of public projects for which the efficient user charges will not cover the total costs of the project. Cost-benefit analysis is almost completely silent on how the differential should be collected. All we really know after this analysis is that, given the postulated values (average benefit of $2.00 or more per trip) there exists a scheme (a set of payments and compensations) for paying for this facility such that, after such payments and

* This idea works better when the groups involved are low income and middle income than when they are middle income and high income. Commuter train charges should peak at rush hour. High income people may find it easier to avoid the peak charges than middle income.

compensations are made, everybody will feel at least as well off and some people will feel better off with the beach rather than leaving the island as it is. Cost-benefit analysis is of little or no help in finding such a scheme and, more to the point, of finding a financing program which is institutionally and politically feasible. If no feasible financing strategy can be found, then the project may have to be abandoned whatever its present value. However, the larger the net present value, in general, the easier it will be to find an acceptable financing scheme and the harder one should look for such a scheme. Thus, from the point of view of financing, cost-benefit analysis is a screening method. Those projects which have positive net present values are candidates for which one should attempt to find a feasible financing method; those which have a negative net present value or are dominated by a feasible mutually exclusive alternative with a greater present value can be dismissed at once.

Even if no politically feasible scheme which compensates all those negatively affected by the investmend can be found, it may be good social policy to undertake a project with positive net present value even though some people are put in worse positions than before, provided that the benefits to others are sufficiently great and widespread. In so arguing, one is taking tacit advantage of the fact that if there are many such projects, one <u>may</u> be able to state that with high probability the law of large numbers will eventually equalize the benefits.

Finally, given political realities, it may be self-defeating to push efficiency in project pricing too hard. Often, if a project is really worthwhile, the inefficiency implied by non-marginal cost financing will be small compared to the overall benefits of the project and, in searching for a financing scheme one should concentrate on political feasibility rather than at attempting to milk the project for the last iota of net present valued benefits. In so doing one should remember that this is not always the case. The net present valued benefit of a project is not independent of the pricing scheme and in some cases this dependence can be crucial. Attempts at average cost pricing of urban mass transit may be a prime reason for its failure.

SUMMARY OF CHAPTER III

This completes our exemplary analysis. We have already commented on its lack of detail and comprehensiveness and will not repeat these caveats here, for they can be overcome by straightforward application of effort. For Lovell Island an actual cost-benefit study might include the preliminary costing of eight or ten postulated combinations of recreational facilities, residential development, and industrial uses and an estimation of their benefits. This process would be iterative in the sense that, in the analysis of these alternatives, it will become clear which modifications of these alternatives should also be studied. We believe it should be clear from our cursory analysis of a single alternative how these investigations should be carried out, the kinds of assumptions that will be required, and the type of judgment which will be required in deciding whether to impute a value or a probability distribution to a hard-to-estimate variable or to present the decision-makers with the results as a function of this variable and let them make a judgment on it either explicitly or implicitly. Thus, if Lovell Island were or could be considered to be an isolated entity, the application of cost-benefit analysis to this resource would present no great conceptual difficulties.

The problem is that Lovell is not a completely isolated economic entity and considering it to be so may result in inefficient suboptimization and it is in this respect that the preceding analysis may be misleading. For example, consider the island transportation system. If Lovell is considered in isolation, it has to bear the full costs of this system. However, if the other islands surrounding Lovell were developed at the same time, all of which were served by the same transportation system, then the development on Lovell would have to bear only the marginal costs of serving Lovell. Since public transportation systems are typically characterized by marginal costs a good deal less than average costs, this would make this transportation appear considerably cheaper from the point of view of Lovell and may change the ranking of the alternative developments on Lovell. Or consider the problem of spillovers. An isolated study of Lovell might conclude that the net present value of the island is maximized by utilizing the island as an oil terminal, which use might seriously decrease the benefit which could be obtained from the neighboring islands due to air, water or visual pollution. Unless this decrease is included in the analysis of Lovell, serious misallocations may occur.

Therefore, as always, the analyst is faced with defining the boundaries of the problem and accounting for the important effects that cross those boundaries. The more comprehensive the boundaries, the less likely one is to leave out important benefits or disbenefits and, at the same time, the more staggering the analysis problem becomes. For example, considering Lovell alone, eight or ten well-chosen alternative developments may cover the range of possibilities quite well. However, in order to consider the harbor islands as a whole, one may have to analyze hundreds of complex alternative developments to be able to say with any degree of confidence that one has located a development which comes close to maximizing the net present value obtainable from the islands. The problem of comprehensiveness versus analytical feasibility is considered in more detail in Chapter IV.

CHAPTER IV

REGIONWIDE DEVELOPMENT STRATEGIES

Introduction

The purpose of this chapter is to lift our view from the analysis of individual projects to the consideration of the efficient allocation of a regional coastal zone taken as a whole. We begin by considering some basic theoretical and practical limitations of project by project analysis which emphasize the impossibility of governmental analysis of all possible allocations of the coastal zone, even if this were a politically feasible or desirable undertaking. Thus, the great bulk of coastal zone decisions must and certainly will remain the province of a complex constellation of decentralized decisionmakers at the individual, local, state and federal levels. The discussion then focuses on what we can say about organizing this structure in such a manner that it will tend to operate toward an efficient allocation of the coastal zone. Finally, we return to a discussion of our basic assumption that society's goal is Pareto-efficiency relative to the present income distribution and reexamine our conclusions in the light of this provisional assumption.

Limitations of Project by Project Analysis

The allocation of coastal areas is just a special problem within the general problem of locational economics. All the problems of zoning, taxation, and striking the right balance between and among public and private uses are present. Since there is basically a fixed supply of land or space, the fixed supply of coastal areas does not make coastal allocation problems unique. The problem may be more acute, however, if there is more demand for the fixed supply of coastal areas. Being more valuable pieces of property, the allocation decisions are correspondingly more important.

The allocation problem should not be thought of as fitting square pegs into square holes and round pegs into round holes. There are a few activities that must be located in particular spots (the extraction industries are the best example), but most activities can be located in a variety of locations on the shore and back from the shore. Different locations may have different associated net present values, but there is not typically only one location with a positive net present value for each project. Thus, the social problem is how to maximize the net present value of all the projects which might be located in an area and not simply to maximize the net present value of each individual project.

The basic problem is that all locational decisions are by nature interdependent through the fact that one project's use of a particular portion of the coastal zone excludes another project from using this particular area. Viewed in this regard individual projects are interdependent and in a sense mutually exclusive.

In a properly functioning market this interdependency would be taken care of by the price of land. Consider the following simple example. Suppose we have only two locations: location 1 is on the shore, location 2 inland, and only two possible uses of these locations. Use A is an industrial plant which after all spill-overs are properly accounted for has a net present value (exclusive of the cost of land) of 10 in location 1 and 9 in location 2. Use B is a recreation facility which has a net present value of 4 in location 1 and 1 in location 2 also exclusive of the cost of the land. Thus, we have the following table.

USES	LOCATIONS 1	2
A	10	9
B	4	1

The first thing to notice is that even if the above figures correctly represent the net social benefits of the respective projects we should not allocate the plant to 1 and the recreation facility to 2, for this would give a total net social benefit of 10 + 1 = 11 while the opposite allocation would yield a total of 13. It costs the plant less to move to its second best location than it does the recreation facility.

Given a properly functioning market for land the desired allocation would be achieved for the recreation facility could afford to bid up to 3 units for location A while it sould pay the plant to bid no more than 1 unit. The market value of location A would be something in excess of one unit more than the market value of location B and the recreation facility would obtain the property.*

Note, however, that even if we deducted the market value of the land in our cost benefit analysis, the results narrowly interpreted would be misleading. Say the land cost is 1.5 units and we examine location A in isolation. The net present value including land costs of the plant would be 8.5 versus 2.5 for the recreation facility and we would locate the plant at A. Apparently, cost benefit analysis points to a demonstrably inferior allocation.

* This result presumes that the organization representing recreation interests is financed in a manner consistent with society's desires. More on this later.

The key to this problem is that the alternatives are not:

1 put plant at A
2 put recreation facility at A
3 do nothing with A

and nothing else. If this were the complete set of alternatives, we should allocate A to the plant as indicated. However, the actual set of alternatives are:

1 allocate plant to A, recreation facility to B
2 allocate recreation facility to A, plant to B
3 allocate plant to A, do nothing with B
4 allocate recreation facility to A, do nothing with B
5 allocate plant to B, do nothing with A
6 allocate recreation facility to B, do nothing with A
7 do nothing with either location

In summary, cost benefit analysis will not lead one wrong if one evaluates the total net present value of the full range of alternatives.* However, the number of alternatives increase combinatorially with the number of possible locations. This then is the basic conceptual limitation on cost-benefit analysis: if one doesn't evaluate the full range of alternatives, then one can be led astray, but the evaluation of the full range of alternatives is generally completely infeasible. This limitation is in a real sense more confining then the more-often-mentioned difficulties in measuring non-market benefits, for as indicated in Chapter 3 this latter problem can be ameliorated by performing the analyses over a range of values for the non-market benefits.

This is not to imply that we believe project analysis to be useless. Far from it, there are dozens of projects suggested for the Northern New England Coastal Zone deserving of searching cost-benefit analysis-projects for which one can usefully hold the rest of the coastal zone fixed while performing the evaluations, projects for which although

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* A famous varient on this kind of error is to trim the set of alternatives down to acceptance or rejection of a 'Master Plan.' in which the accounts of a vast number of projects are pooled and if the net present value of the pooled project is positive all the component projects, some of which may be grossly inefficient, are accepted. The Missouri River and Upper Colorado irrigation plans may be cases in point. (15)

one obviously cannot analyze all possible combinations of locations,one can postulate a representative and workable spectrum of alternatives. A prime example is the proposed Maine refinery. See Appendix C. This limitation does imply, however, that whenever we undertake cost benefit analysis of locational decisions we are engaging in a form of suboptimization with all the dangers attendent there to. And it does imply that only a very few of the multitudinous coastal zone allocations decisions can usefully and feasibly be treated by the type of analysis outlined in Chapter III. It does mean that the great bulk of coastal zone allocation decisions (including those based on these project analyses) will have to be made by a complex decentralized political structure.* The question then is: given what we have seen so far, what can we say about how this political structure should be organized if society's goal is the Pareto-efficient allocation of the coastal zone with respect to the present income distribution?** We shall discuss in turn the following mechanisms through which society can directly control the allocation of the coastal zone:

1) Zoning
2) Property Taxes
3) User Charges
4) Effluent Charges

Zoning

At present, the single most important means of interfering with the private market allocation of the coastal zone is through zoning. Zoning at least in the northern New England Coastal Zone is presently in the almost exclusive control of the local community. Presumably, local zoning was orginally evolved as a means of controlling

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* Conceptual problems aside, good cost-benefit analysis requires considerable time and effort (considerable resources). Only for a few of the most substantial public investments will it be efficient to devote this time and effort for the resulting increase in information.

** And as our simple little example hints a decentralized structure oriented around the private market may be capable of making these decisions in an efficient manner.

negative spillovers and facilitating certain contracts. It was observed that, for example, an industrial use of a site adversely affects the property values of neighboring residential sites. And it was further observed that if all industrial uses were grouped together, the sum total of these spillover effects was less than if they were spread throughout the town. This grouping might not have occured in an unregulated market due to contracting costs. Thus, zoning to effect the desired reallocation was almost universally instituted.

However, at the same time, the towns universally opted for the property tax as a means of generating public revenues for the provision of such public goods as sewerage, access, police protection, and generally education. It became quickly apparent that given property taxes, zoning and the public revenues and costs were coupled. With suitable zoning, a town could control the distribution of income within the community, the age and size of families, and a variety of other factors which have little to do with spillovers or contracting costs. (See Appendix A for a description of one coastal town's view of zoning.) At this point, any proposed zoning change is evaluated primarily on its marginal effect on public revenues and costs. The question becomes: will the change increase the town's revenues more than it will increase the cost of the services it provides? At this point, zoning becomes heavily biased toward small, high income families, industrial and commercial uses (the very uses it originally was designed to control), and most importantly in the coastal zone, in favor of high income summer residences (which generate revenue while placing almost no burden on the town's costs) and away from public recreational facilities (which decrease town revenues while placing a very high burden on costs). Thus, we see that local zoning when coupled with the property tax and local provision of a variety of services can have an entirely different result than that presumably intended originally. Zoning decisions become focused on the parochial benefits and disbenefits of any proposed changes rather than on spillovers.

Still in all, zoning has many real and potential virtues. It is a uniquely effective, and very low administrative cost means of both controlling certain types of spillovers and affecting an efficient geographical specialization of land use.* We shall argue that many of the present misallocations laid to zoning are really a

* The degree to which this specialization can occur is presently limited by the size of the zoning units.

fault of its tie-in with the property tax and an historical overreliance on local coastal zone communities for regionwide public goods. If the changes which we recommend in these areas could be effected, much of the criticism of problems associated with local zoning would be greatly ameliorated.

Be that as it may, some problems would remain and it is not at all clear that the changes which we will recommend with respect to the property tax are politically feasible at least in the short run. Given this, what can we do to improve our zoning procedure?

We have seen that the basic problem is parochial benefits. In so far as parochial benefits are a wash within the purview of the zoning body, that body is likely to concentrate on spillovers as locally perceived and can be expected to improve on the private market allocation. Given that we have a variety of governmental levels at which we could effect zoning, a possible approach is to give control of a particular type of decision to the lowest level at which the parochial benefits resulting from the decision will be a wash. This leads to a hierarchical structure in which progressively more general levels of government have control of progressively more general decisions. Consider the case of a New England refinery. From the point of view of the Federal government, parochial differentials involved due to changes in the state in which the refinery is located will be a wash. Thus, the Federal government could be given control over whether or not a refinery should be built in a particular state. Now from the point of view of the state chosen for the refinery, differentials in parochial benefits due to differences in the township in which the refinery is located are a wash and the state could be given control over picking a township. From the point of view of the township chosen, parochial benefits due to changes in the refinery site within the town are a wash and the town could be given control over the actual site.

It might be both more efficient and more politically palatable if in the actual selection process the system could work backwards with each potential town picking a site which it suggests to the state level, which in turn picks a town, forwarding its result to the federal government level which picks a state or nixes the whole idea. The economies associated with this division of analytical effort are obvious. (Something vaguely resembling this happens now with respect to choice of sites for major expositions or particularly attractive government installations. However, the process might well stand some formalization.)

Unfortunately, as outlined, it would work only for those projects for which the net of the parochial benefits and spillovers within the community were positive. At present large scale non-commercial recreational developments and conservationists uses of the land often represent parochial losses to the community involved.

Thus, if we are going to accept voluntary hierarchical zoning we require a system such that any project which is efficient with respect to society as a whole will appear to be a net benefit to the locality. Given the parochial benefits associated with industrial and recreational projects and the positive local spillovers associated with low intensity recreation and conservation setting up such a system may not be impossible. However, as we shall argue in the next section, in order to arrive at such a situation considerable structural changes in the means by which the towns generate their revenues will be required.

Property Taxes

Property taxation as presently applied in the coastal zone has some serious difficulties. Ad valorem property taxes have macroeconomic problems. They are unresponsive to economic cycles. They become increasingly regressive as the society becomes increasingly wealthy. However, we shall not be concerned with these issues, but rather with their effect on the efficiency of coastal zone allocation. Property taxation as presently applied is intimately tied to private market values (often with a rather considerable lag.) In so far as the market overvalues private uses and undervalues public, a town development policy will react accordingly. This situation is aggravated by the fact that public uses of the land are generally exempted from property taxes altogether. In the absence of a local political body with effective development control, such a property taxation scheme would be biased in favor of public uses of the land and result in underdevelopment by Paretian standards. However, if a town is deriving its revenues from property taxation, it cannot afford to dedicate land to public use and, in fact, strives to dedicate land to uses which have a large differential between resulting private market evaluation of the property and cost of services required. We feel confident that the net effect of property taxation based on market value is a bias toward high income residences and industrial and commercial uses of the coastal zone. It is certainly biased against most non-taxable uses of the land, public recreation and conservation.

It is our opinion that a better alternative would be:

a) The institution of user charges to raise municipal revenues--a fee for sewage, a fee for police protection, etc., all based on the costs of providing that service to each person or structure.*

b) Dependence on broader political units then the municipality for public goods serving more than the municipality such as large recreation facilities and education.

A fee based taxation scheme would still be income regressive. However, we feel that the local municipality is a bad level at which to attempt to effect society's desired redistribution of income. User charges have the advantage that local development decisions would not be biased by income or age or toward industrial or commercial uses. In so far as the public goods which the town provides are subject to decreasing costs and the town charged average costs, this taxation scheme would still bias the local zoning boards decisions toward overdevelopment in general. However, we do not feel that the services being offered are subject to large economies of scale and that these economies of scale will be at least partially balanced by increasing costs due to interference, congestion, and the requirement to use increasingly unfavorable land for even a moderately well developed community. The one possible exception, sewage treatment, also happens to be the municipal service with the greatest spillover cost and since we are going to recommend charging these spillover

* User charges are required by efficiency considerations anyway as outlined in Chapter III. Here we are concentrating on their interaction with political considerations.

costs, there will be a tendency here for the economies of scale to be balanced by increasing effluent charges.

In short, we feel the development bias introduced by user charges will be considerably less than that which presently occurs under ad valorem property taxation. If a new development, whether it be a residence, a factory, or a regional beach, just pays its way as far as the town coffers are concerned, the local zoning board will not be influenced by effects on tax base, etc., and will concentrate on income transfers into the locality associated with the development (bad) and the spillovers (good).

The institution of user charges has one basic conflict with the American tradition (of the last ninety years) and that is the provision of public education without reference to income. At the elementary and high school level this has been handled by the local communities. Obviously, a user charge (an education fee to each family based on number of children being schooled) which would be required if the town's decisions are to be not biased against low income families would defeat the income redistribution aspects of this policy. Therefore, the institution of such a charge would have to be coupled with educational support from a broader governmental level if this principle is to be preserved. This support could take the place of a payment to the town for each child educated or a payment to the parent positively earmarked in some way for education, in which case the private market could be used to provide education. Both these alternatives would provide a considerably more even quality of education then the present system which is clearly biased against the child in low income areas and large cities. A principle seems to be emerging; effect desired income transfers at levels higher than the municipality.

Similarly, user charges will have to be levied on those public developments such as large scale beaches which serve an area larger than the local community. If the town provides sewerage, police or fire protection to this development then it will have to be compensated for this service if its development decisions are to be not biased against such developments. This implies that the public facility will have to be owned by a broader based governmental body representing all the potential users of the development, who will then pay the town for the services provided.

The common practice along the coastal zone of asking the local community to provide region serving beaches--presumably on the basis of parochial benefits, which parochial benefits are most readily capitalized on by the abject commercialization of the beach area--should be ended. If the region wants a beach, it should pay for it directly.

Effluent Charges

Up to this point the discussion has focused on means of decoupling the municipal revenue raising function from the local community's development decisions, for we have seen that, in general, such coupling can lead to coastal zone allocations which are grossly inconsistent with the goal we have assumed for society--a Pareto-efficient allocation of the coastal zone. In this section, we ask in what manner can we use taxation to correct for market failures in the allocation of the coastal zone? We re-emphasize that the general question of how should one interfere with the market in the coastal zone cannot be given a meaningful answer until one is decided on what one wants from the coastal zone. Our provisional assumption again is, that society desires that allocation of the coastal zone which is consistent with willingness-to-pay under the present income distribution. Given this assumption, we will consider taxation of spillovers, or since the major spillover with which we will be concerned involves disposal, effluent charges.

Given our acceptance of willingness-to-pay, it is easy to state the principle by which that level of pollution which is consistent with willingness-to-pay should be determined.

ANY GIVEN POLLUTANT LEVEL SHOULD BE ACHIEVED BY THE LEAST COSTLY MEANS AVAILABLE. THAT LEVEL OF POLLUTION SHOULD BE ACHIEVED AT WHICH THE COST OF FURTHER REDUCTION WOULD EXCEED THE BENEFITS (46).

This will be the level which minimizes the sum of the costs of polluting (damage to people and things, increased production costs to downstream users, opportunities foregone, esthetic disbenefits) and the costs of not polluting (costs of treatment, of changing technology or withholding production). In general, at very low pollutant levels the costs of the pollution are small, but the costs of attaining that level are quite high and vice versa. Efficiency demands that we find the intermediate point at which the sum of these costs are minimum. A necessary condition for level x to be the cost minimizing level is that the cost of reducing pollution one more unit is equal to the increase in the costs of pollution from moving from level x-1 to x. Or more concisely, x will be the point where the marginal cost of reduction equals the marginal social cost of the damages.

We have seen that the unaided market will, in general, yield a higher level of pollution than this, for the polluter does not bear the cost of his pollution. The question then is what kind of market interference will best obtain the desired level. Clearly, some means of enforcing pollution abatement are better than others.

There are three major alternatives with respect to means of controlling spillovers:

1. Direct regulation via licenses, compulsory standards, etc.

2. Payments either direct or through reduction in collections that would otherwise be made, such as accelerated depreciation of control equipment and tax credits.

3. Charges or taxes based on the amount of pollution discharged.

Almost all the present pollution control schemes fall into the first category. However, direct regulation is clumsy and inflexible and loses the advantages that can be obtained by inducing the kind of decentralized decision-making that makes the competitive market such an efficient device under the right conditions. For example, a rule that factories limited their discharges of a particular pollutant to a certain percentage of its total discharge is less desirable than a system of effluent fees that achieves the same overall level of pollution, because with the latter each firm would be able to make the adjustment in the manner that best suited its own situation. Those firms who found it very expensive to reduce the level of pollutants would adjust their output less than the firms who found it cheap to reduce this level. Society would achieve the same level of pollution at less cost to itself.

Thus, economic efficiency points to the latter two categories. With respect to these, we should first point out that it is most efficient to have any system of charges or payments based on the actual level of effluent and not on something that is indirectly related to this level, such as the purchase of control equipment. A payment to firms for decreasing the discharge of pollutants is better than a tax credit on pollution control equipment because the latter introduces a bias against other means of reducing the discharge of pollutants, such as a change in production technology. Similarly, an effluent charge on gasoline would be biased against devices for controlling emissions during the burning of gasoline.

There are two reasons for favoring charges over payments:

a) There is no natural origin for payments. The amount of payment should be based on the reduction in the discharge of pollutants below what it would have been without the subsidy. Estimation of this magnitude would be difficult and the recipient would have an obvious incentive to exaggerate the amounts he would have discharged before subsidy. Furthermore, any potential polluter would have to be paid a subsidy for not building an effluent producing installation. The problems of obtaining the information required to determine the amount of this subsidy would be prohibitive.

b) Subsidies will require the raising of funds by taxes to a much greater degree then cha ges which taxes themselves distort the economy. Furthermore, the distributional effects of a subsidy may be politically unpalatable.

In short, if we are going to be consistent with one of the basic principles of resource efficiency, price=marginal social costs, the social cost of any individual's use of any resource will have to be charged to this individual. Therefore, given our basic premises, there appears to be a clear case for effluent charges. Of course, such a system involves some very real implementation problems and will have to be carefully worked into an overall coastal zone management system.

First, it should be clear that any system of effluent charges or effluent charges combined with regulation will have to be comprehensive. If, for example, a system was applied only to water quality the result would be an overreliance on incineration and industrial processes (such as the kraft pulping rather than the sulphite system in paper making) which would transfer the pollutants from the water to the atmosphere. At least as important the system will have to be comprehensive geographically or the result of the system will be to merely translate effluent producing activities to a location where the system is not operative. This will be especially important if control over the system is to be given to local or even state wide bodies, for these bodies will be concerned with parochial benefits and developers will be able to bargain among these bodies for favorable regulations and levels of charges, and we will be right back where we started from.

On the other hand, the socially desirable level of any given pollutant, as defined above, can vary markedly from location to location. The social costs of polluting a body of water especially well suited and developed for recreation can be much higher than the social costs which will arise from the same level of pollution in a body of water unsuited for other than industrial use. Hence, the cost minimizing level of pollution and the effluent charge designed to achieve that level can be quite different in different locations.*

Problem: who chooses the levels of the effluent charges to be assessed in a certain location or equivalently; who determines the socially desirable levels of each pollutant as a function of location? Who defines the subareas over which the desired pollutant levels are constant? Theoretically, this should be done by determining the social costs associated with each level of each pollutant in each location- a clearly infeasible undertaking. Therefore, in practice it will have to be decided upon by some combination of the political structure. Some ideas on how this structure might be organized are outlined in the last section of this chapter.

For now, we turn to the major technical limitation on an effluent charge system, the cost of monitoring. Of course, any effluent regulation system implies a monitoring problem. However, the requirements for a system which will allow any polluter to pollute

* Conversely, it is true that throughout any subarea over which the desired level of a particular pollutant is constant, the effluent charge on that pollutant should also be constant in order to insure that the marginal costs of reduction of all polluters in this subarea is equal to the marginal social cost of the pollution. This constancy obviously simplifies the problem of determining effluent charges considerably, foronce we have defined a subarea we need only vary the single effluent charge until we find the charge that leads to the desired level in that subarea.

at whatever level he desires and to change the level as he desires--provided he pays the price--imposes somewhat more stringent requirements than a system which sets effluent standards which can be checked intermittently at random times. An effective effluent charge system will require continuous monitoring. For many effluents and in particular large scale industrial and municipal operations this will be no great problem, since the technology is available and the costs of monitoring will be small when compared with the social costs of the effluent. In other cases, continuous monitoring is either very expensive at present usually due to the low concentrations of interest or the monitoring of each unit will be out of line with the costs inflicted on society by that unit. Mercury contamination may be a case of the former and home heating and auto emissions may be cases of the latter.

In such situations direct regulation may be more efficient. This is a classic contracting cost problem. As monitoring technology develops these contracting costs will become smaller and more and more types of effluents will qualify for treatment via effluent charges. For the time being, however, any well designed effluent control system will have to consist of a combination of effluent charges and effluent standards.

There is also a case for subsidy and this involves the classic collective good, basic knowledge. Since knowledge is a collective good, the private market cannot be expected to invest the Pareto-efficient amount of resources in its attainment. In the case at hand, we are referring to basic knowledge concerning the effects of various levels of various pollutants on the environment and the basic technology for rendering the various pollutants more benign. There is a clear cut case for public support of research aimed at this knowledge. Thus, a comprehensive program toward pollution would involve subsidy of basic research, an effluent charge system on all pollutants for which continuous monitoring is efficient, and direct regulation of the remaining pollutants.

Willingness to Pay Reconsidered

This completes our discussion of some of the individual instruments available for coastal zone organization and their relationship to economic efficiency. Before we conclude with a proposal for how these instruments might be integrated into a coastal zone management system, it might be prudent to reconsider the basic limitations of the goal we have assumed for society, consistency with willingness to pay. Essentially, the conceptual (as opposed to arguments concerning the practical difficulties of measuring willingness-to-pay) arguments against willingness-to-pay based on the present income distribution emanate from two basic sources:

a) People do not know what is good for them.
b) The present distribution of income is not socially desirable.

The income distribution problem (b) has already crept unwanted into our discussion at several points. However, we have yet to consider in any detail the problem (a) - difficulties involved with basing choices on willingness-to-pay which in turn are based on incomplete, biased, and sometimes erroneous information.

This is perhaps the major concern of the environmentalists and ecologists. People don't know what they are getting themselves into. At this point, we have to distinguish between two types of lack of knowledge. 1) Things that society as a whole is unsure of, i.e. what is the long term effect of changing the CO_2 balance in the atmosphere? 2) Things that society's experts know but have not yet been disseminated to all the members of society, i.e. what are the possible consequences of changing CO_2 balance and what are the expert's probabilities on these consequences? The first type of lack of knowledge, basically the more important, is not at issue here. It is the kind of uncertainty that can be handled by the methods outlined in Chapter II although, in this example, expected value analysis is almost certainly not appropriate and some means, presumably based on a vonNeumann-Morgenstern-like utility (47), will have to be developed for injecting society's risk adversion into the problem.

The second kind of lack of knowledge is basically a communication or contracting cost problem and communication is costly. Hence, in many cases, the short cut of having the experts apply their knowledge about the consequences of a proposed alternative development directly without consulting the people will be justified. This is essentially what we outlined in Chapter III. However we re-emphasize that the role of the expert here is to specify the consequences and not to say how much people should value this or that consequence. It is our feeling that the valuation be left up to the people, if they can be efficiently informed about the expert's opinion or, failing that, the peoples' elected representatives.

We feel that this division between knowledge and action upon knowledge should be reflected in the government's organization toward spillovers and environmental consequences in general. That is, the agency charged with learning about the consequences of various actitities should be divorced from the agency which is responsible for seeing that this knowledge is incorporated into the coastal zone allocation process. The advantages of removing the first type of function from the political arena should be obvious and is in part reflected in the Stratton Commission's distinction between coastal zone laboratories and coastal zone authorities.(48) However, it appears to have been overlooked by a significant number of environmentalists and ecologists who, in their rush to get their knowledge before the people and have it acted upon, have inextricably mixed this knowledge with their own set of values or the set of values of special interest groups. We feel that the public would be better served if the experts would carefully distinguish when they are acting as analysts ("this in my judgment will be the outcome of this development") and when they are acting as protagonists of a particular value scheme ("therefore, we should not undertake the project")

It is also clear that the experts have a clear responsibility to make their knowledge known to the public. Now information is a classic example of a pure collective good. Therefore, we cannot expect the private market to supply the Pareto-efficient levels of this good. It is clearly appropriate that this good be provided publically and that includes not only the research required to generate the information, but just as important, the resources required to disseminate it.* It appears that with the possible exception of college-level education, the federal government has largely ignored the latter function. In particular, with the exception of information relating directly to the political fortunes of the incumbents, and a few small scale efforts in the public health area the federal government has relied almost entirely on the private market for the dissemination of information to adults.

* It should be clear that if this information is to have any authority, it will have to be disseminated by the information gathering agency rather than the public body actually having control over the allocation.

This brings us to the second problem associated with information in our society: built-in bias. Reliance on the private market for a collective good such as information requires some form of tie-in with a privately marketed good and the private market was not long in coming up with one. The producers of private goods require a means to inform the consumers of the availability of their product and its characteristics. Indeed, this is a requirement for the proper functioning of a competitive market. It was quickly discovered that (a) it was economic to combine the information about the project with other information the consumer was desirous of receiving, since the marginal costs of adding in the other information were quite small and this added information assured one of the consumer's attention; (b) through the shrewd use of psychology one could convince a customer, who would not otherwise buy the product even if he knew about it and its characteristics, to purchase it. Further, and still more important, one could distinguish one's product from someone elses in the consumer mind, establish a partial monopoly and reap the non-competitive profits associated with this monopoly.

Of course, (a) requires that the information that is supplied along with the advertisement is not prejudicial to the product, and further (b) requires that the information supplied along with advertisement be not prejudicial to the customer's psychological receptiveness of the advertisement's "message". Thus, as a result both the advertisement and the information accompanying it are biased. In such a situation, and given the demonstrated effectiveness of advertising, one may well wonder how much faith should be placed on the resulting willingness-to-pay? It is not in the purview of this report to go any further into this area but to merely note:

(a) Willingness-to-pay is clearly a function of the information that an individual receives.

(b) As long as the information that an individual receives is provided by the purveyors of private goods, willingness-to-pay will in some undefined sense be biased toward private goods.

(c) It is not a necessary fact of life that information in a free market society be provided through a tie-in with advertising. It could and, from a collective good point of view, should be provided publically. However, it is obvious that if this option is taken, then very careful controls must be provided to prevent the information dissemination process from becoming a tool of the party in power. There is no a priori reason to believe that such controls could not be worked out.

Let us now turn or rather return to problem (a), the dependence of willingness to pay on the present distribution of income. It is a generally accepted fact that a very important function of government (at least in the United States in 1970) is to effect socially desirable income transfers. Therefore, it is only fair to point out that many authors do not agree with our contention that it is useful to separate distribution of income considerations from efficiency of allocation of resources considerations in evaluating potential public investments. Some people feel that where distributional considerations conflict with efficiency, the problem should be regarded as having a multi-dimensional objective. However, one cannot extremize two conflicting dimensions at the same time (as in the Benthamite "greatest good for the greatest number") therefore, in order to apply extremization, which is the heart of economic analysis, one has to assign weights to the various dimensions. Some hold that we should go to the political process to obtain these weights. (49,50). Others feel that it might be possible to infer these weights from society's past decisions. (51,52,53) Still others hold that the weighting exercise is not useful, and the analyst should merely present the various descriptors dimensions to the people's representatives resulting from each of the alternatives analysed. (54)

With respect to these opinions, our view point might be described as philosophically extreme, but in actual practice pragmatically moderate. That is, we in essence hold that society's desired income transfers should be accomplished through lump sum of income tax social security payments transfered rather than public investment. As Steiner points out, this is convincing only if one thinks that such transfers will actually occur. (55) That is true, but one may well ask "if society desires the distribution of income, why isn't it taking advantage of these relatively more efficient means of doing it. Why should we have to use a relatively inefficient means of accomplishing this redistribution? Some models of the democratic process quickly lead to an egalitarian distribution of income (56) The question is where should the burden of proof be? On those who hold that a rather substantial change in the distribution of income is one of society's goals or on those who hold that we have the political mechanisms to effect the desired distribution of income if we really want to? Our tendency is to go with the latter fully realizing that the actual political animal, despite one man-one vote, is stacked in favor of the status-quo.

However, the real defense of our concentration on economic efficiency as a social goal is that it is useful. We can learn things from it. It has allowed us to be precise in stating in just what sense the private market can be said to be a failure and this precision has in turn pointed toward certain and away from other remedies. It has allowed us to exhibit a methodology, cost-benefit analysis, through which at the very least we can rule out suggested investments which are inconsistent with any of the set of values which would result from any reasonable redistribution of income. Most importantly, it has allowed us to distinguish between true economic benefits and parochial benefits which latter effects are not net benefits under any desired distribution of income, unless one is willing to assume that society actually desires a distribution of income on the basis of geography, rather than need.* In short, we believe that whatever the short comings of accepting Pareto-efficiency based on the present distribution of income are, through this assumption we can sharpen our knowledge about what should be done with respect to the coastal zone. In this respect the report will have to speak for itself. If at this point, the reader feels he has not increased his understanding about the coastal zone allocation problem, then this thesis, or at least our presentation of it, certainly remains open to question.

Summary - A System for Managing the Coastal Zone

Perhaps the basic thesis of this report is that the institutional measures that society has evolved to correct market failures in the coastal zone usually have not only not corrected these failures, but in concert have often exacerbated them or at least replaced them with other sorts of inefficiencies. Thus, present imperfection is a necessary

* We should point out that this view point has been defended on the basis that society has made such decisions in the past. See (57). We believe that a more reasonable explanation of these decisions is that the representatives of all the people are not responsible to all the people, thus allowing parochial benefits expression at the federal level through log-rolling. Furthermore, the parochial disbenefits to the rest of the country were probably not clear to the representatives of the rest of the country at the time that any one such project was up for consideration.

but not sufficient argument for an institutional change. One must also argue that the proposed change will achieve the desired result and achieve it efficiently which can be a much more difficult argument indeed. With these sobering thoughts in mind, we are going to outline a suggestion for a coastal zone management system. While we would be the last to argue that this far from completely developed system is"the" answer to coastal zone management, we do offer it as an example of a system which is consistent with some of the principles of resource allocation which we have developed earlier and one that overcomes some of the more glaring imperfections in the present system with respect to economic efficiency.

The plan is not particularly original. To a large degree it is an amalgam of ideas that have been around for some time. However, the particular combination is probably unique and at least it will yield a starting point for discussion which is somewhat more developed then the completely general guidelines contained in present (1970) coastal zone management bills.*

The system we have in mind is outlined in Table IV.1. The basic rationale behind this particular organization is an attempt to allow expression of society's willingness to pay for collective goods and avoidance of negative spillovers while at the same time not allowing or at least not encouraging competition among political sub-bodies on the basis of parochial benefits. The key features of this plan, some of which have been alluded to earlier, are:

1) provision of municipal services through user charges,

2) a strong state level agency responsible for defining and enforcing environmental standards throughout the area under its control,

3) federal approval of the state level environmental plan enforced by contingent federal funding of the state level organization.

Under this system the locality would be responsible for the provision of the standard list of public services: police, sewage, access, with the exception of education.

* S3183, S2802, and S3354

TABLE 4.1

A SYSTEM FOR MANAGING THE COASTAL ZONE

Federal

Responsibilities

- Standards for zoning, effluent charges, regulation
- Approval of state environmental plan
- Standards for state C/B studies
  - Interest rates
  - Non-market benefits
  - Environmental effects and costs
  - Leave out parochial benefits
- Fund Education
- Research

Enforcement Mechanism
- Federal funding of state land use/coastal zone authority

Support
- Income taxation

State

Responsibilities

- Develop and get environmental plan approved
- Levy effluent charges and regulate effluents for which continuous monitoring is inefficient in accordance with plan
- Approve large scale projects
- Acquire land and develop recreation and conservation projects
- Lease off-shore properties and license water column
- Conduct and call for C/B studies in support of above

Enforcement Mechanism
- Courts, Preemptive fines

Support
- Land acquisition and development: state general funds
- Operating expenses and studies: state - federal

Local

Responsibilities

- Provide local public services, local zoning, siting of state approved projects

Support
- User charges

These services would be supported by user charges using average cost pricing if necessary, although the municipalities would be encouraged to use marginal cost pricing schemes.

Municipalities would be free to band together for whatever purpose- water supply, sewage districts, etc.-- for the purpose of achieving any economies of scale obtainable therefrom. The municipality would pay effluent charges to the state level and be subject to regulations of the state level. Local zoning would continue subject to meeting these regulations and charges. The locality would have control over the local siting of large scale, state level approved projects and have recourse to the courts if it opposed a state level approved project.

The state level would have the following responsibilities:

1) Develop and obtain approval from the federal level for a statewide environmental plan which would set pollutant levels by subareas which subareas would be defined by the plan. The plan would include the state's territorial waters.

2) Levy effluent charges and/or make regulations designed to achieve these levels. These charges and regulations would, of course, apply to municipal as well as private sources.

3) Lease offshore properties and license water column resources in accordance with the plan.

4) Acquire land and easements and develop recreation and conservation projects.

5) Conduct and/or call for cost-benefit studies in support of above.

The environmental plan would divide the state into a number of subareas and designate pollutant levels for each such subarea. The state would submit this plan to the federal level plus plans for enforcing the standards in order to get federal support for the state level organization. If the plan met standards formulated at the federal level it would be approved. The state level would then have responsibility for enforcing the plan by levying effluent charges constant throughout a subarea on those pollutants for which the monitoring required by effluent charges is efficient and by regulation where it is not. Thus, the state plan would serve as a generalized zoning device effecting any state wide specialization deemed desirable. Since the local level would be supported by user charges which would have to be levied without discrimination and the state plan could not be altered without federal approval , a developer would have a hard time finding out just whom he sells his parochial benefits to. It might be prudent to require that the state level give its explicit approval to projects above a certain size as a safe guard against loop holes in the master plan with recourse to the courts if the developer feels that an unapproved project is consistent with the master plan. The state level would be responsible for acquiring land for and developing large scale recreation and conservation projects.* The state level would have to be empowered to perform (or require the developer of a proposed large scale project to furnish) cost-benefit studies in support of the above responsibilities.

The development of the statewide environmental plan would of course involve not only the state's coastal zone, but also inland portion and its atmosphere. We have already seen that an incomplete approach to spillovers can result in an allocation which is at least as inefficient as the private market allocation. Thus, at the very least very close coordination will be required between the state level organization concerned with the coastal zone and the bodies with responsibility for the air and inland resources.

The federal level would have responsibility for setting standards to which the state level environmental plans would have to conform. This would include definition of the set of effluents to which the state plan would have to

* An unresolved problem is what to do about effluents emitted by state level projects. If the state collects effluent charges, then any charges these projects pay will be washes on the state account and, at least, theoretically, the state will have no incentive to economize on these effluents. There are several possibilities for handling this such as, have the state pay its effluent charges to the federal level or simply rely on bureaucratic parochialism. An agency which is being charged an effluent tax which goes to the general coffers probably will still act to decrease this tax.

address itself and guidelines as to acceptable levels for each of these effluents by subarea land and water use. The federal level would then approve those environmental plans which met those guidelines. Those states which obtained approval would be eligible for federal support of the state level agency's operating and analytical effort. The federal level would also set standards for the state level cost-benefit studies. These standards would include interest rates, valuations of non-market benefits, social costs of environmental effects and requirements to insure against overcounting of parochial benefits. The federal level would have access to the state level cost-benefits studies and federal funding would be contingent upon those studies meeting federal standards. The federal level would undertake the research necessary to draw up and update both the environmental plan guidelines and the cost-benefit study standards.

Under this system, coordination between neighboring states would have to be insured by continuity requirements in the respective plans. Thus, if the border of two states were a river or estuary, in order for the plans to be approved both plans would have to call for the same effluent levels in the bordering body and the same level of effluent charges in the neighboring sub-areas.

Obviously, this is a very incomplete outline of what would necessarily have to be a very complex system frought with a great many political and technical difficulties. It is offered more as an exhibit in favor of the argument that it is possible to develop political organizations which will allow expression of environmental and other non-market values while at the same time suppressing counter productive competition among political sub-bodies on the basis of parochial benefits. Unless we can do both, we cannot expect an allocation of the coastal zone which is consistent with our own individual values.

Postscript

Drafts of this report have been criticized by people whom the authors respect on two grounds:

1) The report is too speculative. It makes judgments where conservative economics would require withholding judgment until our theoretical foundations are more firmly planted, until more data is in.

2) The report is too conservative. The problems facing our coastal zone are so immense, so critical that an attempt at dispassionate, private market oriented analysis misses the entire point and amounts to nothing more than jargon riddled bushbeating.

Despite their conflicting nature, both of these views are well taken. The report is overly speculative It is not as closely reasoned nor as carefully qualified as might be desired. This is a preliminary attempt to explore the applicability of still developing principles of economic efficiency to the complex problem of the coastal zone. It is meant to stimulate discussion, not all completely friendly, raise problems, and mainly to try and get our thinking straight about such matters as social values, pervasive market imperfections and parochial benefits with respect to the coastal zone. It is merely a starting point and given the state of the art a non-speculative starting point would be no beginning at all. However, the reader should be aware that we have taken some still-not-completely-developed theories and twisted and squeezed them in a rather violent manner in an attempt to wring out some insights on a very complex and messy problem.

However, the main reason for this postscript is to speak to the second set of criticisms, for the authors share the feeling that with respect to our employment of the coastal zone we must do better than we have been in concentrating on being precise about what we mean by "better", in concentrating on being precise on how a society in which each man is free to follow his own values ends up with coastal zone utilization inconsistent with those values, in concentrating on the necessary trade-offs and losses implied by any reallocation, perhaps this basic conviction no longer manifests itself.

Our guess is that the difference between what the life of the people in the American coastal zone is and what it could be, fully considering all resource constraints and as measured by the people's own values, constitutes a tragedy of momentous proportions. We fully expect matters to become worse, perhaps drastically worse, under continuation of the present coastal zone management system. We are sensitive to the fact that the difference between our present and probable utilization of the coastal zone and what it could be like is microcosmically mirrored in the difference between the Chicago waterfront in 1910 and that waterfront in 1930, and yet only one man has the vision to see the feasible potential. (58). If this feeling does not emerge, then the report is quite properly faulted.

However, it is also our conviction that even if, as our analysis seems to indicate we are seriously misusing our coastal zone, dispassionate analysis of why we are making the mistakes implied is required before one can prescribe remedies. One must be aware of the basic resource constraints and the trade-offs involved before one can identify a particular change as desirable on net. One must be aware of the mechanism through which our present coastal zone management system makes mistakes before one can recommend institutional changes. A preliminary attempt at developing this awareness is the methodologically speculative and philosophically modest goal of this report.

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APPENDIX A

ALTERNATIVE DEVELOPMENTS OF HULL

A.1 Introduction

The town of Hull was selected for study as an example of a long-established shoreline town which has traditionally provided recreational opportunities for its year-around residents, for summer visitors, and for the general public. There have been amusement parks and related activities as frequently found in beach resorts since the latter part of the 19th century. In 1900 the Metropolitan Parks Commission acquired for general public use a substantial part of the magnificent Nantasket beach on the Atlantic Ocean side of town. Its holdings now amount to 1.3 miles of ocean front, about one-third of the total. Hull has also been attractive to summer vacationers many of whom have owned their own seasonal homes, while others have rented cottages or rooms. The summer population has traditionally been much larger than the permanent population. However, Hull seems to be groping toward new development patterns. It seems possible that governmental action might help the town to accommodate itself to these patterns and at the same time provide greater public access to Hull's recreational facilities for the general public in the Metropolitan Boston area. The object of this particular study was to explore these possibilities.

A.2 Geography

Geographic considerations affect the development of any community to some extent, but rarely are they as pervasive in their influence as at Hull. The town is almost entirely surrounded by water. Excluding several islands under its jurisdiction (Bumkin Island, Peddock's Island, and Hog Island) the town consists of a long narrow peninsula. It is bounded on the east by the open waters of the Atlantic Ocean, on the north by outer Boston Harbor, on the west by Hingham Bay, and on the southwest by the Weir River and Straits Pond. At its southern extremity, where it borders on Cohasset by land, it is tied to the mainland by a strip only a few hundred feet wide, barely large enough to carry Atlantic Avenue, one of the three roads leading out of town. The other two exits (George Washington Boulevard and Nantasket Avenue) cross the Weir River on bridges to tie the peninsula to routes leading north through Hingham and west through Cohasset. The map,

Figure 3.1, shows the general configuration.

On the open water side, from the Cohasset line near the end of Straits Pond in the south, the peninsula extends to the northwestward for about five miles to Point Allerton. At that point, the land swings sharply to the west for about two miles more, ending at Windmill Point in Pemberton. Thus, the town is about seven miles long. Irregularities in configuration are such that the total shoreline length is about 21 miles, islands excluded. Yet the total land area (including the islands) is only 2.43 square miles.

The Pemberton section of the town in the north, originally an island, is connected to the peninsula proper at Allerton by a causeway. The Pemberton and Allerton sections are hilly, with highest elevations of about 100 feet. There are also several small hills (50-100 feet high) on the western edge of the peninsula and in the southern part of the town. But most of the land is low relief upland (10-20 feet in elevation). There are also some tracts of marshland on the Weir River estuary side of town. But most of the land is low relief upland (10-20 feet in elevation). There are also some tracts of marshlands on the Weir River estuary side of town. On the eastern (Atlantic Ocean) side of the town there is a magnificent beach about 3.5 miles long extending from Nantasket to Point Allerton. Several smaller beaches to the south of this stretch bring the total ocean beach length to about four miles.

The geography of the town is such that almost any point is within a short distance from the water. From much of the town it is easy to walk to the Atlantic Ocean beaches. The hills afford splendid water views of ocean, harbor, bay, river, or salt pond. Hull is dominated by water, a fact that has played a large part in its past and present development and that will strongly influence its future.

Second only to the dominance of water is the relative isolation of the town from the mainland. From Pemberton to the center of Boston is only about seven miles as the crow flies, while the airline distance from central Boston to the Hull-Cohasset line is about 13 miles. But there are only three roads leading from the town to the interior. Atlantic Avenue runs almost due east to join Jerusalem

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Road, a scenic route along the Cohasset shore. To go to Boston or to the interior of the state, Hull residents must travel in great arcs around Hingham Bay, Quincy Bay, and Boston Harbor. The most direct route involves exiting southwestward via George Washington Boulevard to Hingham and proceeding north through Hingham, Weymouth, and Quincy to pick up the Expressway into Boston at the Neponset River. This involves a trip of something like twenty-five miles, much of it through heavily built-up areas. The alternative is to proceed southeastward, southward, and westward on Route 228 and finally northward on Route 3 and the Expressway. Total route length is about 33 miles, of which about 10 miles consists of winding roads through Cohasset, Hingham, and Norwell where high-speed driving is impossible.

There is no rail or rapid transit service to the town. At one time it was possible to take a street railway from Hull to Hingham where connections were made with the Old Colony Railroad. Both have long since disappeared. There is a bus service from Hull to Hingham where connections can be made with other lines to Boston and neighboring towns. There is also a daily commuting service by boat from Pemberton to Rowes Wharf which accommodates some 40-50 people daily. Departure is at 7:30 A.M. and return at 6:30 P.M. This trip takes about 40 minutes each way.(1) The inadequacies of public transportation are such that most Hull residents must depend upon their own cars to get them out of town whether for work or for other purposes. Traffic surveys indicate that, even though travel time to Boston by private automobile must average between 40 minutes and an hour, 60 people drive to Boston to go to work for every 1 travelling by public transportation. For non-work trips, where time and schedules are of lesser importance, the ratio is less dramatic; but still the automobile is preferred to public transportation by 3.3 to 1.(2)

The third geographic factor of importance is that Hull has little to offer industry or commerce. The original settlers engaged in fishing, but that no longer is an economically viable enterprise, save for a small amount of clamming.(3) During the 17th, 18th and 19th centuries there was undoubtedly some farming but there is none today. Lacking rail facilities and deep water, with no usable sources of water power, and isolated from population centers, the town was bypassed during the industrial expansion of New England in the 19th and 20th centuries. Moreover, there are no resources that can be mined.(4) Save for those engaged in local service industries and in mercantile business, meeting the needs of Hull's own inhabitants and summer visitors, the people of Hull who have to work also have to go elsewhere to find it.[5] Since there is little more to offer in the neighboring towns of Cohasset and Hingham, most of those who leave town to work have to travel considerable distances--to Quincy, or to Boston, or even farther.

A.3 Hull Developmental Patterns--1900-1945

Given this combination of beach and water, relative closeness to the city combined with isolation from it, and lack of features attractive to industrial developers, one would expect that Hull would be a natural resort area catering both to day trippers and seasonal visitors. And, in fact, the town developed along just such lines during the period from the turn of the century to the end of World War II.

By 1900 Hull was already well along the road to development as a resort town. In that year the Metropolitan Parks Commission (later incorporated into the Metropolitan District Commission) took over jurisdiction of part of Nantasket Beach, opening it up to use by the general public. In that year also there were 892 houses in the town and a permanent population of 1703.[6] The latter paid real estate taxes of about $800,000 while nonresidents paid nearly four times as much (just over $3,000,000). Ten years later the population had grown by about 25% while the number of houses had increased by about 75%. Nonresidents owned about four times as much property as residents and contributed about 77% of the real estate taxes.[7]

This same pattern continued through 1930. The permanent population actually had declined by 1920. By 1930 it was almost back to the 1910 level. By 1940, it had barely passed that level.Nonresidential construction continued to add to the number of houses up to 1930, but with the onset of the Great Depression building came nearly to a standstill. As we shall see, building revived after the war, but nonetheless, as of 1960, 73.5% of Hull's housing stock had been built before 1939 (most of that before 1930) and 45% before 1920. (8) Nonresidents were undoubtedly contributing between three and four dollars in real estate and personal property taxes for every dollar paid by residents for the support of the town.Since the summer people made few demands on the town, chiefly police and fire protection,and paid such a large share of the cost of schools and general government, Hull was a cheap place in which to live.

A.4 Growth after World War II

Beginning with World War II, the pattern of Hull's development underwent a radical change. While only a handful of new houses were built during the war years, the town's population increased by about 56% between 1940 and 1945.(9) This growth represented, for the most part, an influx of workers in the Bethlehem Steel Company shipyards in nearby Hingham and Quincy. Housing was provided by conversion of summer residences to year-round occupancy. By 1950 the population had declined a little as some of the war period workers moved elsewhere with the dropping off of activity at the shipyards. But at about that time a new influx of population began with the result that the number of permanent residents more than doubled between 1950 and 1960. The 1969 population of about 10,000 is nearly triple that of 1950 and more than four times that of 1940.(10)

Perhaps 1000 new homes have been built since 1940, most of them in the period 1945 to 1960.(11) Since 1960 new construction has almost been balanced by demolitions of existing structures. Accommodation for the newcomers, therefore, has largely been provided through conversion of older summer places to permanent homes. Nor is this process finished. In 1950, 69% of the houses in town were not occupied except during the summer; by 1960 this had dropped to 47%; today, summer homes probably still make up 30-40% of the existing housing stock.(12) Hence, even with little or no new construction there is considerable potential for population growth by adaptation of existing housing to permanent occupancy.

A.5 Characteristics of the Town

Hull is a working man's town. The lower middle class population is almost entirely Caucasian, about 43.5% of foreign stock or foreign born. As compared with the Boston Metropolitan area, it has more than the average percentage of laborers, service workers, private household workers, craftsmen and foremen, sales personnel, and managers, officers and proprietors. Compared to the same standard, Hull contributes fewer than average numbers of professional and technical personnel, clerical workers, and operatives.(13)

In 1960 about 17% of the families had incomes over $10,000 as compared to 21.3% for the Boston Metropolitan Area. In that year, both the average family income ($7,350) and median family income ($6,318) were lower than for the metropolitan area as a whole. It is a young population, with 43.5% 19 or under in 1960 as compared to 35.2% for the Boston Metropolitan Area. The median number of people per dwelling unit was 3.4 in Hull, and 3 for the metropolitan area. Most Hull residents live in single-family dwellings (89.2% in 1960); most own their own homes (72.3% in 1960). Only 4.4% of these single-family homes were valued at $20,000 or more in 1960, as compared to 25% for the Boston Metropolitan Area as a whole. The median value of such units in Hull was $12,900 as compared with $15,900 for the entire area. On the other hand, median rents tended to be higher ($97 per month) for Hull than for Boston as a whole ($82).(14) The latter can be explained by the relative shortage of multi-family dwellings and by the high rentals obtainable for housing during the summer season; property owners will demand a rental premium for year-round occupancy because of the possibility of obtaining relatively large sums for summer use only.

Hull's growth has not brought prosperity to the town. Between 1958 and 1963 the number of retail establishments decreased by 28%, their sales declined slightly, sales per capita were off by 21%, and the number of employees had dropped by 25%. All business activity showed a decline between 1963 and 1966. Payrolls were down by 12.5% and the number of employees by 29%; average salaries were up slightly from $3,340 to $4,140 (or 24% for those still employed).(15)

At the same time, the cost of government, especially of schools, has increased dramatically. As most suburban towns have discovered, even the addition to he tax base represented by new construction is not sufficient to cover the demands for services (especially schools) generated by new families. But in the case of Hull the problem is particularly acute. Since 1960, new houses have meant, typically, addition of from $15,000 to $17,000 per unit to the town tax base During the same period, conversions of existing property to year-round use have meant an average increase in taxable value of the properties affected of something like $2,000-$3,000.(18) Of course, the newly-converted homes have been heavy consumers of town services (again, especially schools); before conversion they had helped pay these costs for others while making few demands on the town. Moreover, the personal property tax base, which has in recent years run at about 10% of the real estate base, is also subject to erosion as summer homes are converted to permanent residence. Save for boat owners and businessmen, few permanent residents in Massachusetts towns pay personal property tax because of a generous exemption afforded each household. Since it is presumed that summer residents are taking advantage of this exemption elsewhere, it is standard practice in resort communities to assess these property owners for personal property as well as real estate taxes. As summer homes pass into the hands of year-round residents, therefore, the personal property assessments must drop off. Finally, the steady demoliton of older properties in recent years undoubtedly reflects the impact of constantly increasing taxes on owners of deteriorating summer properties that might have been, under other circumstances, patched up and kept on the tax rolls.

Another problem needs to be taken into account. A few of the hilly sections of Hull installed sewers many years ago which discharge untreated waste into Hingham Bay and the Weir River. The rest of the town depends upon septic tanks and cesspools located on the building lot to take care of sewerage. The town is now under order by the Commonwealth to install sewers and a treatment plant to stop the serious pollution of the bay and the river. Ultimately, it will be necessary to tie the homes now depending on domestic waste disposal systems into the municipal sewer. Even though most of the soil is sandy, the domestic systems have always been hard-pressed because of the heavy demands put upon them by the large summer population (estimated at 40,000 people not counting day visitors)(19) and the small lot sizes (mostly 5,000 square feet). Now, with constantly increasing year-round occupation of homes in the summer resident areas, problems from overflowing cesspools and septic tanks have become of increasing concern to local health officials.(20) Even with state aid, construction of the necessary sewers and treatment plant will represent a heavy cost to Hull's taxpayers.

A.6 Recent Trends

Most of Hull's residents have moved into the town since World War II. They came to Hull because the town offered a combination of cheap housing and excellent summer recreational opportunities for adults and children alike. Lack of local business and industry meant that most of the new inhabitants had to face long daily commutation stints. The town lacks modern shopping facilities. During the summer season the residents of Hull must put up with crowding of the streets and beaches. As has been noted, the summer population climbs to about 40,000 people. This does not count the masses who stream in by bus, private automobile, and steamer to enjoy the public beach at Nantasket and the nearby amusement park area. It has been estimated that on a hot summer weekend day this influx may amount to 60,000-80,000 people. The resulting traffic jams sometimes get so bad that the police are forced to impose an embargo on any further traffic into town on such days.(21) But--considering the benefits--the inconveniences of long commuting trips, of going elsewhere to shop, and of occasionally horrendous traffic snarls seemed a small price to pay.

Moreover, there was no comparable alternative available to the newcomers. The nearby shore towns of Hingham and Cohasset had much less to offer in terms of recreation, while real estate prices were perhaps double or triple those for Hull.(22) Farther to the south, Scituate and Marshfield did offer somewhat similar recreational opportunities, but at an even greater distance from Boston in terms of road miles and probably of time as well until the opening of the Southeast Expressway. While these towns have also experienced rapid population growth, partly through conversion of existing summer homes, zoning regulations have been tighter and lot size requirements greater. The result has been that real estate costs, while much lower than for Hingham and Cohasset, have tended to be considerably higher than at Hull.

The problem facing the people of Hull has become one of wondering if they will be able to stay there. The taxes on a $12,900 house owned by a family with an income of $6,318 (the median values for 1960) were $555 in 1960; by 1968 they had risen to $890, with the end nowhere in sight. It is doubtful that the median income had experienced anything like the 60% increase in real estate taxes. In 1950 the average Hull taxpayer (resident and nonresident alike) had turned over $240 to the Collector of Taxes; by 1960 the bite was $465; in 1968 it was $775. By 1968 it was costing the town about $600 per child for education (salaries, expenses, transportation) not counting new building expenses.(23) The average taxpayer with children in the schools was not coming close to meeting the costs of education of his family, let alone his share of other services. The flywheel of nonresident tax payments was chiefly responsible for keeping the situation under some degree of control, but, as has been shown above, that flywheel was losing momentum.

Projection of past trends presents an even grimmer picture. Let us suppose that Hull should attempt to continue to develop as a lower middle class bedroom community. This would mean building single-family homes on all currently vacant land and finishing the job of converting all summer homes to year-round occupancy. What effects would such a development have on the town?

Let us assume that a development pattern of this sort would have the following results. Five hundred new homes would be built at an average value of $17,500, adding $8,750,000 to the tax base. Two thousand summer residence units would be converted to permanent homes at an average cost of $5,000 each, adding another $10,000,000. About $2,750,000 in personal property assessments would be dropped from the rolls with the elimination of the summer residents, even after taking account of increases in personal property taxes levied against new boat owners and new small business ventures. Let us also assume that new businesses add $5,000,000 to the real estate property tax base.(24)

Given the above assumptions, there would be a net increase of $21,000,000 over the present $45,000,000 personal and real estate tax base. The population would probably double. The costs of local government would at least double and more than likely triple.(25) If they doubled, the annual tax levy would amount to about $6,300,000 to be raised on a base of $66,000,000. This yields a tax rate of $95.50. If they were to triple, about $9,500,000 would have to be raised against the same base. This implies a tax rate of $144. If we assume an average home value of $15,000, the Hull citizen could look forward to a tax bill of $1,430 in the one case and of $2,180 in the other.

Recognition of this unpleasant set of facts has led the people in recent years to try to change the direction in which the town is moving. In 1961 the town established an Urban Redevelopment Authority (the first such at the town level in the entire country). While progress has been painfully slow, plans have been drawn up for redevelopment of a badly decayed business and residential area near the MDC public beach. Federal funding was obtained to support the necessary planning studies and final approval is pending for a Federal grant to clear the area of existing buildings and thus open it up to development. The necessary zoning changes have been approved by the town. The plan contemplates construction by private interests of a 100-unit motel, two 100-unit apartment units (1 and 2 bedrooms), a shopping plaza, and a marina. The motel and apartments will be on the ocean side, the marina on the bay, and the shopping plaza more or less centrally located. It is anticipated that the apartments and the motel alone will add more than $4,000,000 to the tax base. Construction of the marina will await the necessary dredging and elimination of pollution in the Weir River; its anticipated value has not yet been costed.(26)

The redevelopment project includes additional public parking near the beach on the northern end of the project. (The motel, apartments, and marina are to have integral parking.) The shopping plaza will have access to a reserved section of the MDC parking lot. the 407,000 square foot lot will provide space for perhaps 1,400 cars; only several hundred can be presently accommodated in this general area of the beach under present arrangements. Jurisdiction over the town beach in the area has been transferred to the MDC, giving it about 1.3 miles of beach as compared to 1 mile formerly.

Thus, in its urban renewal program the town has moved to add to its tax base without incurring heavy costs for schools and other services. One- and two-bedroom apartments are generally not associated with large families. At the same time, it has increased public access by non-residents of the town to Nantasket Beach. Once this project has been successfully completed, further renewal efforts are planned to revitalize decaying commercial and residential areas in the general vicinity of the public beach.(27)

Over and above the urban renewal programs, Hull has undertaken an effort to upgrade the town through zoning changes which were approved by a special Town Meeting as recently as 20 October 1969. The new zoning by-law opens up the last major tract of vacant land in the town (excluding the islands) to garden apartment development (1 or 2 bedrooms). A long stretch of the oceanside north of the redevelopment area has been rezoned to permit construction of hotels, apartment houses and town houses, and associated services such as restaurants. Another large tract on the bay side has been similarly zoned; this area could attract marina developers as well as hotels and multi-family dwellings. As before, the multi-family dwellings in both areas are to be restricted to 1- and 2-bedroom units. Two smaller areas in the more northern parts of town and the two larger islands are similarly zoned. Other sections have been zoned for various types of business or commercial enterprise or for multi-family dwellings, while about half of the town remains zoned for single-family residences.(28)

To make the plan work, lot size requirements have been altered. Lot sizes for single-unit residences have been changed from 5,000 square feet to 6,500. This just about rules out rebuilding on most existing lots. On the other hand, two adjacent lots can be combined to meet the minimum requirements of 10,000 square feet for multiple family dwellings. Coupled with these basic requirements are restrictions on lot coverage and requirements for setbacks and parking that are designed to provide for open space.(29)

Thus, it is Hull's hope that it can capitalize on its unique location by encouraging the development of improved seasonal facilities such as hotels, motels, and marinas, and by fostering the construction of multi-family housing designed to appeal to people of a higher income bracket and smaller family size than the present norm for the town. To accomplish this it has opened up some of the prime land in the town to such commercial development and made it difficult, over the long run, for these areas to remain primarily dedicated to single-family residences.

The impact of this scheme, if it works, should be to provide a substitute for the summer resident in terms of contributing to the costs of running the town. The new enterprises will add to the tax base without creating the kind of load on the schools that is associated with single-family dwelling development. The development of controlled commercial recreation in prime areas now mostly zoned for single-family residences will also afford some increased public access to Hull beaches and waters. However, this will not be mass recreation of the sort found at the Metropolitan District Commission (MDC) beach and its associated commercial amusement area, but the type which might attract high income, low number of children families. In short, Hull is attempting to find a way to permit its present population to keep their homes by attracting higher income residents and visitors.

In our opinion, it is not clear that, even given this limited objective, Hull's present plans will be successful. There is no doubt about Hull's uniquely attractive geography, yet except for the marina the plan takes little advantage of it. The results for which they are hoping will be another example of the uninspired garden apartment-shopping center complex which could easily be built and has been built almost anywhere in suburban Boston. Such developments attract young, small, but hardly high income families and, in fact, development along these lines will make it more difficult to attract high income residents in the future.

Further, the plan does not attack the key problem in attracting high income residents and recreation which is transportation to Boston. High income, low number of children people are urban dwellers or persons with easy access to urban areas for employment and recreation. Hull's major problem from the point of view of these people is getting to Boston. If one could get to downtown Boston in, say, 20 minutes with reasonable schedule frequency, then a whole spectrum of opportunities arise: high-rise residence development, townhouses, hotels, restaurants and nighttime recreational facilities catering to Boston residents, etc. Hull could easily become the new outlet for Boston's burgeoning demand for high income, urban residences. Until the transportation problem is solved, Hull, despite its unique geography, can at best expect to be a poorer version of the communities surrounding it to the south, which have more land and better access to Boston, for Hull will always be crowded by suburban standards.

We further feel that if Hull's transportation problems are to be solved it will be by taking advantage of the short over-the-water distance to downtown Boston either through conventional vessels, hydrofoils, or ground effect machines. It may very well pay the present residents to subsidize such service on the grounds of future effects on property values and taxes. (This argument is, of course, based on parochial benefits.) Hull does not appear to have investigated this possibility and neither have we. Our basic point in this section is to demonstrate that, whatever decisions Hull makes as a political entity, they will be only remotely related to economic efficiency.

A.7 Hull as Part of the Region

Thus far in this discussion we have been proceeding as though the Town of Hull were largely free to conduct its affairs in a manner that the inhabitants as a body think will best suit their own interests. Given that this is a free enterprise system and that the town retains the pure democracy of the open town meeting, there is a certain amount of truth to this implicit assumption. Nonetheless, it is important to point out that there are constraints operating which limit Hull's freedom of action.

The power to force development in desired directions by zoning regulation, for example, is derived from the Massachusetts legislature and is not inherent in the corporate charter (which also was of legislative origin). Arbitrary or discriminatory use of this power could lead to legislative withdrawal or modification of zoning authority.(30) The urban redevelopment process is dependent upon approval and financial support from the Federal Government as well as action by the citizens of Hull. The urban redevelopment process has enacted legislation requiring the cleaning up of polluted waters; as a consequence, the Commonwealth has ordered Hull to construct sewers and a treatment plant to eliminate its present pollution of Hingham Bay and the Weir River. Hull will receive some financial aid from the state in this endeavor, but it has no choice in the matter. By 1972, the present pollution must cease.(31)

Hull's chief assets are the waters of the bay and river and the great beach on the Atlantic Ocean. Optimum development on the bay side will require dredging for the construction of marinas. This cannot be done without approval by the Army Corps of Engineers. If development in the Weir River estuary will require the filling or draining of some of the existing marshland, this cannot be done without prior approval from the Massachusetts Department of Natural Resources. Hull's beach is publicly owned, about two-thirds by the town and one-third by the Metropolitan District Commission, an agency chartered by the Commonwealth. The town can exert some degree of control over parking regulations directed against nonresidents. The MDC area is open to all comers who can find means of transportation to the area. The MDC provides its own police force for the reservation, as well as lifeguard and maintenance services. Hull not only has no control over the area, it even pays an annual assessment to support the MDC operation. This amounted to about $47,000 in 1968, for example.(32) When automobile traffic becomes so heavy as to threaten chaos as the result of preemption of all legal and illegal parking spaces and very heavy congestion in the streets, the Hull police can exert some control by imposing an embargo on further incoming traffic into the town. Such measures are adopted only rarely, however.

Another factor affecting Hull's destiny, yet beyond its control, is the lack of good land transportation into the town. There is no rapid transit service to Hull, nor do plans for southward extension of the MBTA lines call for service to the town. Barring development of improved transportation by water, Hull must continue to depend upon bus service and the private automobile. This means reliance upon two of the three roads leading out of town. There has been discussion for years of an improved road to the north more or less along the shoreline to be known as the Shawmut Trail. Intense oppostion on the part of Hingham, Weymouth, Quincy, and Braintree through which the road would have to pass has apparently made this proposal a dead issue. Hull's other hope lies in development of a new limited access, high speed highway to replace the present inadequate Route 228 as a link to the Southeast Expressway. As a resolution adopted during a Special Town Meeting in November 1968 stated, this road is "the economic lifeline of the Town of Hull" and action to accomplish its relocation should be started "as soon as possible."(33) But the towns through which it will have to pass, notably Hingham and Norwell, have done everything possible to delay and frustrate the laying out and construction of this new road.

To summarize, Hull has exercised local initiative to attempt to force new development patterns that will reverse the recent trend of costs rising much more rapidly than the supporting tax base. As the Chairman of the Hull Planning Board put it in urging enactment of the new zoning regulations, all Hull has to sell is the water. This, he said, is "liquid gold." The town owns "the finest beach from here to Florida." To expand the tax base it is necessary to give developers an incentive to develop the waterfront. Hull, he further noted, is at a "point of no return." "Look at your tax bill," he cautioned. The rezoning was designed as a "money proposition" to "make money for the Town of Hull."(34) The same general line of argument underlies the urban renewal effort, though the techniques employed are, of course, quite different.

But, in the last analysis, Hull's success or failure in achieving its objectives will depend heavily upon forces outside its control. If the necessary Federal funds from the Department of Housing and Urban Development are not forthcoming, the urban renewal project will never get off the ground. If better transportation links with the interior and with Boston are not provided, there will be little incentive for private capital to take advantage of the new opportunities presented by the revision of the Zoning By-law. The recent expansion of the MDC area may lead to a modest increase in public recreation usage of Nantasket Beach, but Hull's plans do not call for maximum usage of its assets in the general public interest. Rather, they represent a blend of local and regional interests, with the accent--naturally enough--on the local.

What are the parochial benefits and costs to Hull of the annual summer incursion of nonresident inhabitants and day-trippers? The following are at best crude estimates but they are probably accurate within 10%. The chief contribution is, of course, in tax payments. As late as 1968 nonresidents and businessmen whose chief activity is related to summer trade probably accounted for about $250,000 of the $276,000 in personal property levy. The same groups probably contributed something like $1,600,000 of the total $2,878,000 real estate tax levy.(35) In both cases, the chief contribution is derived from the ononresidents, with relatively little attributable to those catering wholly or primarily to day-trippers.

The next big item to be considered is summer employment, which in July is twice as large as in November.(36) Assuming the same general pay scales, this would mean a payroll of about $600,000 for the summer season. Not all of this would go to Hull residents, of course, but we can assume that perhaps $400,000 of it would. Hull receives about $40,000 a year from licenses and permits;(37) perhaps $30,000 of this is attributable to summer business. Parking meter fees add up to about $2,000; these are wholly related to summer activities, since the meters are in operation only during the summer months. Probably about $9,000 of the $12,500 received in fines and forfeitures from the Plymouth County Court are also derived from summer offenses, especially parking and motor vehicle violations.

It is clear that the nonresidents provide a major part of Hull's municipal income. What do the summer inhabitants add to the costs of running the town? Since they own about half of the property, we will charge them for half the costs of the tax collector and the assessors, or $21,700. Extra police hired for the summer cost $21,500. Police protection during the summer, and of their unoccupied property during the winter, should account for about $50,000 out of the total of $268,000 for the Police Department. Marginal fire protection costs, summer and winter, are estimated at $175,000 out of a total Fire Department cost of $382,000. Beach Patrol and Harbormaster add up to $11,000. Beach cleaning tacks on another $11,000. Out of a total recreation and related item budget of about $45,000, we will charge the summer residents with the entire summer recreation budget of $11,000. Their pro rata share of the costs of trash collection amounts to $30,000 out of a total of $71,000. This assumes no economies of in garbage collection. All of the above adds up to $311,700.(38)

This figure represents less than 6% of the total cash budget for the year and less than 15% of the total raised by taxes on real and personal estates. But this group probably paid about 51% of the real and personal taxes directly; if we add in the contributions from businesses largely dependent upon their support, their contribution increases to about 59%. The nonresidents are still, obviously, a great asset. The one-day visitors may not be, though they certainly generate some income to the local residents and some revenue to the town as noted above.

Hull pays the MDC about $47,000 a year as its share of supporting the Metropolitan Park System. In return, the MDC provides police services, lifeguard protection, beach maintenance, and trash collection in its area. The MDC pays Hull about $6,000 for the use of its dump for disposal of refuse.(39) Were Hull to have to provide the services now furnished by the MDC, the costs might be about as great as the present assessment, assuming the same general public access as at present. Under these conditions the direct costs and benefits would appear to be a wash, while the town does derive other benefits from the employment and taxes derived from businesses directly supporting those enjoying the use of the beach and the nearby commercial recreational facilities.

On the other hand, had the MDC reservation never existed and had the 116-acre area been developed for private commercial and residential use, the Hull tax base might be about 10% larger than it now is. In 1968 this would have meant an extra $4,500,000 to be assessed; if $2,500,000 of this represented nonresidential and commercial property, the 1968 tax levy might have been on the order of $3,300,000 instead of $3,155,000 and the tax rate $66.50 instead of $69. The average household would have paid about $25 less in taxes to the town. It is not certain that the citizens of Hull feel that they derive $25 worth of benefits per household from summer invasion by hordes of steaming humanity by boat, bus, and private automobile with the consequent crowding of beaches, stores, restaurants, streets, and highways.

A.8 Increased Public Use of Hull's Beaches

Hull's preferred development pattern, if it can be made to work, will lead to a higher population density both summer and winter than now obtains. But it is not clear that it will lead to greater usage by the general public of the day-tripper variety. On hot summer weekend days the beaches are already crowded to an almost incredible degree. While the limit would seem to be parking space, this is true only so long as people obey the parking regulations. According to residents, on peak summer weekend days the visitors park wherever there is space, on public or private property (if undefended), paying no attention to posted restrictions.(40) Some feel that payment of a $10 parking fine for a day on the beach with their families is worthwhile.(41)

A number of officials have confirmed the seemingly fantastic estimates of a daytime population (including residents, summer visitors, and day visitors) of more than 100,000 people on such days. The density on the beach is such that the people who live there, or are staying there for the summer, remain at home. Even so, there is not even room to put down a blanket.(42) On such occasions the beach loading becomes comparable to that at Coney Island, with perhaps as little as 10-15 square feet of dry beach space per person, as compared to accepted recreational standards of 75 square feet per person.

Indeed, as the new zoning regulations take hold, the general public may find its access to the beach actually reduced. The hotels, motels, and luxury apartments will have their own off-street parking, and access to this will be strictly controlled presumably. Moreover, as high income producers to the town, they may well be in a position to demand and receive support from the police in the form of traffic control and strict regulation of parking on the streets, since the attractiveness of their developments depends upon a free flow of traffic.

It might be possible to increase public usage of the beach in the newly-zoned area by construction of parking garages back from the shore. However, it is not certain that such an operation would pay. There is no shortage of free parking in Hull during the non-summer months. Thus, a parking garage would have to depend upon a summer season of about 100 days to meet all expenses.

Estimated cost of a garage holding about 440 cars would be about $1,400,000.(43) At 5% for 20 years this could be amortized by an annual payment of $113,000. Maintenance, labor, insurance, and so on, might add another $37,000 in annual operating costs, bringing the break-even point to $150,000 per year. On average, there will be 70 weekdays and 30 Saturdays, Sundays, and holidays during a 100-day season. If the garage is open 12 hours a day, we can assume 125% utilization on the weekends and holidays and perhaps up to 100% on the weekdays. This works out to 47,300 (car-parking) days during the season. If a flat fee were to be charged, it would require about $3.25 to cover capital and operating expenses, neglecting taxes and profits. Assuming an assessment of $1,000,000 and the 1968 tax rate, taxes would add about $70,000 annually. Assuming a gross profit of about $30,000 is required by the entrepreneur, the total annual costs would come to about $250,000. This implies a parking fee of about $5.25 if a flat rate were to be charged.

Presumably, people would be willing to spend more for parking on weekends and holidays than they would in mid-week. If the charge for the premium days were set at $7.50 and for the others $4.00 and if the utilization were as postulated, the garage would meet all expenses, including taxes, and pay the suggested profit. It is not entirely clear, however, whether people would pay this much or if the suggested utilization factors could be realized. If we assume an interest rate of 10% and a fifteen-year write-off, the annual capital charges become approximately $184,000. Leaving all other costs as before, the garage will have to clear about $320,000. This implies a flat-rate parking fee of nearly $7.00. Alternatively, weekday fees of $5.00 and weekend fees of $9.00 would provide the required income. It is even less clear that people would pay this much. The conclusion, therefore, is that parking garages do not appear to be an attractive business proposition.

Even if we assume that additional parking facilities could be made to pay (whether publicly or privately owned), there is a limit to the number of people that Nantasket Beach can accommodate. And that limit is already approached or exceeded on hot summer weekend days. The fact that a public beach and (currently) free public parking exist at Hull acts as a magnet to draw the inland population to the town. When they find that so many others have had the same idea, that there is no more legal parking and no more room on the public beach, the natural reaction is to intrude on areas nominally reserved for the residents of the town. The mere existence of general public facilities gives these out-of-town visitors the feeling that they have a right-of-access to the beach. Having gone to the trouble to get there, they are not ready to turn around and go home again, even though this may mean affecting the rights of others.

Paradoxically enough, the natural conflict between local and regional interests is sharpened, not lessened, by dedicating part of a scarce resource to general public use. Hull's residents undoubtedly feel that they have done a great deal for the general public in turning over more than a third of the town's beach to them. They resent movement of outsiders into areas reserved for those who live in the town. They receive important disbenefits in the form of traffic, confusion, and so on, even when the day visitors keep to the MDC area. They feel that they should be left free to enjoy the rest of the beach, since it is the possible use of the beach that has led them to buy homes there or to pay heavy summer rentals. As noted above, the out-of-town visitors care little about such niceties. They want to go to the beach, period.

When the population pressure was less this conflict was not so sharp. Few people lived in the town permanently. They undoubtedly received benefits, either directly or indirectly, from the money spent in the town by the visitors to the MDC area. Most of Hull's development took place before 1920, in the pre-automobile era. Thus, it was not easy for those using the MDC beach at Nantasket to intrude in great numbers on the portions of the beach used by residents. Now, with a larger population demanding access to the shore and with the mobility resulting from widespread ownership of automobiles, the picture has changed.

Where the local interests involve only a handful of people it is possible to resolve such conflicts by expropriation in the name of the higher general good. This was done on Cape Cod when the National Seashore was established there. It might happen some day in towns such as Duxbury where a beach as good or better than Hull's is largely restricted to purely local use. In cases such as these, general regional planning can proceed almost as if no local interests are involved, as if the development were starting from scratch. But, in cases like that of Hull, where the local interests are substantial and where provision for the general interest has already imposed real costs on the local inhabitants, the answer to regional problems would appear to lie in sympathetic attempts to make the best possible adjustments of the present conflicts, not in imposing new usage patterns from on high.

If Metropolitan Boston is going to need more and better public recreation facilities, it will not be able to squeeze them out of towns like Hull. The answer will almost certainly have to be found in the creation of brand-new recreational opportunities in areas now not so employed at all or available only to a handful of the people in the region.

A.9 Possible Governmental Roles

Hull is already obtaining Federal assistance in its urban redevelopment efforts. The state (Metropolitan District Commission) provides police and maintenance services in the part of the beach under its jurisdiction, though Hull does have to share in some of the costs of this operation. (It paid a levy of about $47,000 in 1968.) The state will also share part of the costs of the new sewage system which it is requiring Hull to install. There seems to be little else that government can do to assist

Hull in solving its problems or to provide better access to Hull's facilities for the general public. As noted, those facilities are already used to near capacity much of the time, and reach a saturation point on occasion.

One possible exception is to be found in the two uninhabited islands in Hull Bay. While Hull's new zoning ordinance contemplates development of these for commercial recreation, it may be that they could be put to better use as part of an integrated public recreational development of the Harbor Islands. Should this be done, it would be desirable to provide Hull with some compensation for the acquisition of these potentially valuable assets. Also, it would seem only fair to plan the financing and operating of the project in such a way that Hull was not expected to pay a major contribution towards the costs simply because the islands lie within its political jurisdiction.

A.10 Conclusions

Hull's potential is already being fully employed, or nearly so, during much of the summer season. On hot weekends the beaches and roads become saturated to the extent that the local police have to embargo any further automobile travel into the town.

While more recreational facilities are badly needed in the general metropolitan area, it is not easy to see how these can be provided at Hull short of tearing the whole town down and transforming it into a public reservation. This would be politically impossible and economically inefficient. Hull aready suffers a great deal of inconvenience, and some costs, as a result of the summer invasion of hordes of day-trippers. While the nonresident homeowners more than pay their way, it is not certain that the town receives compensation from those using the MDC beach commensurate with the inconvenience and other indirect costs incurred by the residents (both permanent and summer).

It is always difficult to balance regional and local interests, perhaps especially so at Hull. It would be difficult indeed to convince the people who own property at Hull that measures to provide even greater public access to their resources would be to their benefit. Where such resources are so controlled by local private or public owners that they are grossly underutilized in terms of the larger need, good arguments can be made for taking the property with compensation. Since Hull's beaches are already used by a very large number of nonresidents, this argument does not hold for further public development there. Any further increase in the use of Hull by nonresidents (Peddocks Island and Bumkin Island excepted) could only serve to lessen the advantage of the town to the residents without granting them any compensating benefits. The townspeople and their elected officials could be expected to resist any such plan strenuously and effectively.

Through redevelopment and new zoning, Hull is attempting to cope with a serious cost of services problem. The old character of the town as a bustling resort dominated by single-family summer houses and practically empty in the winter is changing. The conversion of summer residences to year-round homes increases the costs of services much more than it does the tax base. Present residents are asked to subsidize the education of incoming children. Hull has instituted plans to attract high-income, small-family households by encouraging apartment construction and rezoning. It is not clear that these plans take sufficient advantage of Hull's geography or sufficient cognizance of the importance of access to Boston.

In summary, the decisions made by a locality such as Hull are based almost entirly on parochial effects. They are divorced both from the discipline of the private market and from considerations of regional welfare. Their value and efficacy depend almost entirely on the imagination and wisdom of a few town leaders who often represent special interests within the locality itself and rarely command the technical training or experience to see the locality as part of the region nor the financial powers to implement plans based on such a viewpoint.

APPENDIX A FOOTNOTES

1. Information provided by Mr. John Tierney of Hull Redevelopment Authority staff.

2. 1968/1969 Transportation Facts - Boston Region (hereafter cited as Transportation Facts).

3. At present Hull's clam flats are closed because of pollution.

4. There is sand on the beaches and offshore, but any mining of this would be strongly resisted by the town, the metropolitan District Commission, and the State Department of Natural Resources.

5. "Land Utilization and Marketability Study, Town Center Project #1, Hull, Massachusetts," (9 October 1967), prepared by Giroux and Company for the Hull Redevelopment Authority. (Hereafter cited as Giroux)

6. Data on number of houses is to be found in the assessors reports in the Annual Report of the Town of Hull for the year cited. Population data are from the Annex, unless otherwise noted.

7. Through 1910 the annual assessors reports broke the assessments into resident and non-resident categories. Later estimates based on numbers of houses, population, and (for 1920) examination of published list of value of properties which showed about four times as much property in the hands of non-residents as belonging to residents.

8. See Giroux.

9. 1969 population estimate from Hull Redevelopment Authority.

10. There were 3106 houses in 1939 and 3163 in 1946. In 1968 there were 4076. There have been perhaps 100-200 demolitions during this period as well.

11. See Giroux.

12. Ibid.

13. Ibid.

14. School costs taken from Annual Reports.

15. Assessment data from Annual Reports.

16. Based on analysis of building permits data in Annual Reports and interviews with Mr. John Tierney of Hull Redevelopment Authority.

17. The 40,000 figure appears in the report of the Board of Health - Health Agent (Annual Reports 1966). Mr. John Bray a longtime resident and Executive Director of the Hull Redevelopment Authority, believes that the summer population is more likely something less than 30,000 but that the day trippers would easily raise it to more than 40,000 on an average weekday.

18. See reports of Board of Health in Annual Reports. For instance, in 1968, 195 sewage overflow problems and 28 drainage of surface water problems were reported. In 1967, there were 288 and 30, respectively.

19. Information supplied by Hull Police Department and confirmed by MDC Police, Nantasket Division, and Messrs. Tierney and Bray of Hull Redevelopment Authority.

20. Giroux gives some data on comparable real estate values. Additional information obtained in personal interview with Walter Hall Realty Company personnel.

21. Tax levies based on assessments for the years indicated. Education costs from Annual Report (1968).

22. These estimates have deliberately been made on the high side. If past trends continued, the new housing would not have such a high average value and the conversions would run at about $3,000. As noted earlier, the actual trend in recent years has been one of decline, not growth, as the population expanded.

23. The chief problem, of course, would be school costs. Low-cost housing would continue to attract young people with large and growing families as in the past.

24. See Hull Redevelopment Authority brochure, Those Thirty Acres, and Giroux.

25. Information from Messrs. Bray and Tierney of Hull Redevelopment Authority.

26. See Hull Zoning By-Law as revised by Special Town Meeting of 20 October 1969.

27. Ibid.

28. See report of Permanent Sewer Commission in Annual Report (1968).

29. Transportation Facts.

30. Annual Report (1968).

31. Address from the floor by Thomas Cox at Special Meeting, 20 October 1969.

32. These are estimates

33. See Annex.

33. Data on income to town treasury from Annual Report (1968).

34. Data on expenses from Annual Report (1968).

35. Annual Report (1968).

36. Interview with Mr. John Bray of Hull Redevelopment Authority.

37. Information from MDC Police - Nantasket Division.

38. Interview with Mr. John Bray.

39. Costs based on costs of garage built at M.I.T. in 1961, adjusted for inflation. Data supplied by Mr. Robert Cavanaugh of M.I.T. Buildings Department.

APPENDIX B

THE PILGRIM POWER PLANT

B.1 Introduction

The Boston Edison Company is presently constructing a 655 megawatt nuclear power plant on 500 acres of shoreline property on Cape Cod Bay four miles south of Plymouth, Massachusetts. The site contains about 4000 feet of rocky shoreline and will include two stone breakwaters 2000 and 900 feet long, standing 16 feet above mean low water.

The study group thought that the investigation of the wisdom of this location would enable us to demonstrate the application of some of our cost-benefit techniques, the feeling being that there might exist substantial external costs associated both with the plant's thermal effect on the marine ecology and with the effects of an industrial installation on neighboring residential and recreational properties.

B.2 Effects on the Marine Ecology

The plant's circulating water system has a flow rate of 320,000 gallons/minute which removes 4.38×10^9 Btu/hr of heat. The full power temperature rise is 28°F. The water velocity into the intake structure is 1.5 ft/sec, while that at the discharge structure is 8 ft/sec.(1) The intake water is taken from about 8 feet below mean low rates (12 feet below msl) while the discharge is at the surface at mean low water. The prime reason for the low level and low speed of the input is to avoid mixing of the warmer surface waters into the coolant. However, these characteristics also make it possible for all but the slowest species to avoid being sucked into the cooling system. The coolant water is carried in three ten-foot pipes: two inlet and one discharge to the reactor structure. The maximum of the mean daily temperatures at the site through the 1967 and 1968 summer is 65°F at the surface and 57°F at the seabed in 20 feet of water.

A physical model of the thermal pattern of the effluent was constructed at M.I.T. The horizontal scale was 1:250 and the vertical scale 1:40. The model was run under several tide and current situations which in this area runs essentially parallel to the shoreline, flowing SE on the incoming tide and NW on the outgoing. However, these tidal components are very small, and thus the current at any time depends primarily on the time history of the wind. The heated plane was confined to the upper five feet of water. Table B.1 shows the surface areas within the various isotherms as observed on the scale model. These areas were observed to be essentially independent of the tide and current situations. Since the ambient temperature is rarely above 65°F in the subject areas, it is only in a very small volume that temperatures above 80°F will be experienced.

These low temperatures are primarily a product of the general coastal current which flows southward along the entire northern New England coast. This coastal current is an extension of the Labrador Current. Its diversion to the east by Cape Cod results in a sharp increase in the summer seashore temperatures on the south side of Cape Cod, making Cape Cod a formal barrier. The current also sets up a counterclockwise motion in the nearly circular bay.

The cooling effect of the coastal current is aggravated in the summer by the prevailing southwesterly winds which produce surface water flow out of the bay which is compensated for by a subsurface flow of cooler waters into the bay. As a result of this effect, Plymouth is known among bathers to be as cold a swimming area as beaches 50 miles north of Boston.

On the other hand, the occasional northeaster will reverse this effect and can raise the temperature of the water in the bay by as much as 10°. Thus, it will be during a late summer northeaster that the temperature rise in the water in the discharge will be most critical to the marine inhabitants of this water.

Economically the most important marine activity which may be affected by the plant's thermal output is lobstering. In the 2400-acre area between the two ledges which bracket the plant site, some 10,000 lobster pots are fished at the height of the season. The Massachusetts Division of Marine Fisheries placed the total 1966 Plymouth lobster landings at 550,000 lobsters.(2) Local sources estimate that something less than half of these lobsters came from areas off the plant site. These lobsters would have a gross landed value of some $300,000.

It appears that the plant will have almost no effect on the lobster population since what little temperature effect there is is confined to the upper five feet of water. However, lobster larvae are planktonic or free swimming for the first two or three weeks of life, often swimming on the surface during this period. It is possible that these larvae could be affected by the plant either through the thermal effluent or by being sucked into the system.

It is symptomatic of our present state of knowledge of the sea that it is not known whether the population of adult lobsters in the plant area grow up in the locale or migrate into the region over the bottom as adults from offshore populations, as many people believe. Even if the lobsters do spawn in the area, they will certainly not be affected by temperature rises of less than 5° (acclimated lobsters, both adult and young, can withstand temperatures up to 85°), and the surface area which has a greater rise is less than 70/2240 = 3% of the local lobster fishing area. Further, the fact that this intake is 8 feet below mean low water and the larvae prefer the surface implies that it is unlikely that they will be swept into the coolant stream. This low intake will also have advantages from the point of view of fouling for species, such as barnacles, dwell in the very near surface waters.

We conclude that with high probability the thermal effect on the local lobster population will be insignificant.

There is only one other marine activity of economic importance in the area (currents prevent silt deposition for shellfish grounds and the density of lobster pots makes fin fishing difficult) and that is the harvesting of the alga, Irish Moss, whose collagen is used in the papermaking and pharmaceutical industries. This plant grows attached to rocks and stones from the low water level to a depth of 25 feet. It requires, therefore, a rocky bottom. The shoreline in front of the plant is the center of a mile-long belt which contains the only presently harvested Irish Moss south of Maine. The annual harvest of Irish Moss from the area amounts to about 750,000 pounds (dry weight) and supports one family and about 15 college students during the summer. Its landed value is certainly less than $50,000 annually. Its marginal net value is undoubtedly less than half this amount.

Little is known about the temperature sensitivity of Irish Moss other than it does not grow south of Cape Cod and, therefore, is undoubtedly more sensitive than the lobster. Once again, if we can assume that the rise must be at least 5° for any noticeable effect, then the affected area will be a small percentage of the harvesting area. Perhaps of more importance will be the disturbance to the plant population during construction of the breakwaters. This may be balanced by the additional sites for growth provided by the completed breakwaters. In any event, the owner of the industry has gone on record at public hearings that he does not disapprove of the plant.

In summary, the effects of thermal effluent on the local marine ecology do not appear lare primarily because:

a) the waters into which the discharge takes place are extremely cool even in the summer.

b) the thermal effects are limited to a very small portion not only of the overall area of the body of water, but even of the local fishing grounds.

TABLE B.1

Dimensions of and Area within the Predicted Isotherms for Surface Temperature Rises above Ambient Temperatures for the Pilgrim Station

Temperature Rise above Ambient (°F)	Length of Area (ft)	Width of Area (ft)	Predicted Area (Acres)	Comparable Area* Surface Cooling Only (Acres)
20°	430	110	1.1	248
10°	1100	250	6.3	725
5°	3400	900	70.3	1203
3°	5900	1300	176	1557
2°	8400	2200	425	1834

*This column is shown for purposes of comparison only, and represents the area within the designated isotherms which would be required if the temperature reduction resulted only from surface cooling.

B.3 Solid Wastes

Table B.2 summarizes the solid wastes discharged by the plant into the bay.(3)

Sodium hypochloride is used as an antifouling agent in the salt water cooling system. It will be used at levels which will result in a residual concentration of free chlorine in the discharge waters of approximately 1 ppm. This is 5-10 times the lethal concentration for most bacteria and is close to the threshold for the majority of plants and plankton under continuous exposure. The last column of Table B.1 indicates that little surface cooling occurs in the high temperature waters, thus the decreases in temperature can be regarded as indicating the amount of dilution of the effluent. For example, a temperature of 3° above ambient would indicate a dilution factor of approximately 28°/3° or 9. Thus, one can argue that toxic concentrations of chlorine will be confined to an area of tens of acres.

However, the long-term effects of less than immediately toxic levels of chlorine in marine organisms is not well known. It is known that low levels of chlorinated hydrocarbons have the ability to markedly decrease the photosynthesizing capabilities of phytoplankton. Thus, this effect bears watching.

In the effluent of estuaine power plants in the Chesapeake significant greening of oysters has been observed and this phenomenon has been traced to copper in the condenser tubes released by corrosion and concentrated by the shellfish. There has been no analysis of this problem for Pilgrim. It can be expected to be less of a problem because of the lack of oysters and clams in the discharge area and the greater dilution. Nonetheless, the heavy metal concentration in the local lobsters should be monitored carefully.

The annual release of radioactivity into Cape Cod Bay is estimated to be between 7 and 50 curies.(4) This radioactivity will be primarily in the form of isotopes of cobalt, manganese, iron, chromium, and zinc. Assuming 50 curies/year, the radioactivity of the circulating water will be on the average increased by 90 picocuries per liter or about 2% of the maximum permissible concentration in potable water, according to the AEC. At present, the radioactivity of the coastal waters is about 300 picocuries per liter.

TABLE B.2

SUMMARY OF ESTIMATED ANNUAL STATION EFFLUENTS

DISCHARGED TO CAPE COD BAY

Type	Annual Volume	Annual Radioactivity Additions	Chemical or Heat Additions
a. THERMAL(1)			
Circulating Water	1.5×10^{11} gals	Below limits of 10 CFR20(2)	4.3×10^{9} Btu/hr(3)
Service Water	5.5×10^{9} gals	Below limits of 10 CFR20(2)	7.8×10^{7} Btu/hr(3)
B. RADIOACTIVE			
Clean Radwastes	Normally reused in station		
Chemical Radwastes	4.0×10^{6} gals	7-50 curies	8.6×10^{5} lbs of Na_2SO_4
C. NON-RADIOACTIVE			
Make-up System	2.9×10^{6} gals	None	66,000 lbs of dissolved solids and 2,200 lbs of particulates

(1) Normal operation at rated load.

(2) Ocean cooling water is naturally radioactive. The radioactive content of the station effluent will be increased slightly during the controlled release of liquids from the radioactive waste system. The liquid effluent from the radioactive waste system will be below the limits specified in 10CFR20 after mixing with the cooling water.

(3) Addition of hypochlorite to these systems is expected for about one hour each day resulting in residual chlorine of approximately 1 ppm in the effluent during this period.

The extent to which this added radioactivity will build up in the bay depends on the amount of interchange between the bay's waters and those of the open ocean. This interchange is a product of three forces:

1) tidal currents;

2) the counterclockwise rotation of waters in the bay due to coastal extension of the Labrador current;

3) wind-induced currents.

The volume mean depth of Cape Cod Bay is about 100 feet and the average tidal excursion 9.3 feet. Thus, the fractional change in volume of the bay during one tidal cycle is 9.3%.

Pritchard indicates that 70-80% of the water which leaves a coastal bay on an ebbtide returns on the next flood tide.(5) We feel that, due to the extremely wide mouth of the bay and the fact that tidal actions move a unit of water only about 6 miles per cycle at the mouth, a higher proportion of the ebbtide waters will return. Therefore, we feel that perhaps 90% of the waters that leave the bay due to tidal action will return on the next tide. This implies that $2 \times .09 \times .1 = .018$, or something less than 2% of the bay's volume will be interchanged per day due to tidal action.

Of more importance is the counterclockwise flow described earlier. Integration of the velocity isopleths of this current indicates a mean absolute flow of .3 ft/sec. The area of the mouth of the bay is approximately 1.6×10^7 ft^2. If we assume that the one-way flow extends over 1/3 of the mouth, then the volume of water moved is about 1.4×10^{11} ft^3 per day, which is about 9% of the volume of the bay.

Calculations of the interchange due to the winds requires wind current data as a function of depth, which is presently unavailable. However, surface currents generated by wind averages about 2% the wind speed and it is well known that in the Cape Cod Bay area the wind currents are almost always considerably larger than tidal currents. Further, winds can persist from the same direction for several days. A 15-knot wind for 48 hours will move surface waters 15 miles considerably further than the tidal excursions we expect at the mouth. Therefore, we expect the winds to be at least as important an interchange mechanism on the tides.

In summary, the net interchange of 10% per day suggested by Pritchard does not seem unreasonable. This implies that the mean residence time of any pollutant in the bay is about 10 days.

The amount of water processed through the plant in a 10-day period is about 6.2×10^8 ft^3 which is about 1/2500 of the volume of the bay. Thus, it does not appear that general radioactive build-up will be a problem. However, the ability of shellfish to concentrate radioactive metals is well known. Therefore, the concentration of radioactivity will have to be carefully monitored in the local lobster.

In summary, it does not now appear that this plant will have any great effect on the neighboring marine ecology. However, certain important uncertainties remain. We note with approval Boston Edison's funding of a $277,000 study of the ecological effects on the marine biology to extend over the two years preceding the start-up of the plant and the two years following.

We suggest that this study could usefully be tied into the Marine Biology Laboratories' detailed biological survey of the entire Cape Cod Bay conducted over the last two years under O.N.R. sponsorship. We also feel that provisions for long-term monitoring of the local ecology should be made. Finally, we should emphasize that our tentative conclusions about the biological effects of this plant are not generalizable. By American standards, Cape Cod Bay is an unusually cold body of water with quite unique flushing characteristics. It is doubtful if such a combination exists in more than a handful of areas long the United States coast.

B.4 The Benefits and Costs Imposed on the Surrounding Land Areas by the Plant

The other area where the plant can effect costs and benefits not accounted for in the marketplace results from the introduction of an industrial operation into a light-to-medium density residential area. It was thought, for example, that the plant could have substantial effects on surrounding summer property values.

The property begins just south of Rocky Point, a 50-foot-high outcropping, north of which the shore turns sharply westward. As a result, there are no shoreline

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The property begins just south of Rocky Point, a 50-foot-high outcropping, north of which the shore turns sharply westward. As a result, there are no shoreline residences to the north of the plant from which the plant can be seen. To the south of the plant, there is another shoulder placing the plant in a hollow. Further south of the plant the shore turns slightly westward. As a result the plant can be seen only from several hundred yards of non-plant shoreline property. Interviews with seven of the twenty-two homeowners in the area indicated that, in their opinion, the plant had had no effect on property values and that, in their view, the effects of the increased local payroll (during construction the plant employs 400 people and it will have a permanent payroll of 50 people) more than balanced any detrimental effects. Only one person, the owner of a cranberry bog surrounded by plant property, has expressed opposition to the plant, but she was unable to marshal any support from other local interests. However, since the survey was taken in October, no summer residents were included, who presumably would place less value on parochial benefits.

The land behind the plant rises to 300 fet within a mile of the shore, placing the entire plant below the skyline and thus decreasing the visual impact to any offshore observer.

Finally, an interesting example of internalization has occurred in this problem. The owner of the property abutting the plant to the south and thus most affected by it was the owner of the property upon which the plant is presently building. Thus, in buying the property, the power company had to compensate this individual for the costs they would impose on him as a neighbor.

In short, it appears that the perceived external costs of the plant are small and more than compensated, in the neighbor's view, by the plant's effects on the local economy.

We must emphasize that, from the region's point of view, this latter is a wash. The same effects would be observed wherever the plant was located. The only exception to this statement is if there are differentials in unemployment in the region. If there are differentials in unemployment, the opportunity cost of labor to the economy will be lower in the high unemployment area than in the low unemployment areas. Since a private utility company operates on market wage rates rather than marginal social costs of labor, this can result in inefficient plant location in the face of variations in unemployment. However, these differentials are unlikely to be large in even a moderately free labor market with a moderate amount of worker mobility. With respect to the case at hand, Plymouth was suffering a higher than regional unemployment rate due to the closing of the local cordage industry. On the other hand, it would be interesting to know how many ex-ropemakers are working on the plant. In summary, the parochial benefits to the economy of the neighborhood of the plant's location should rarely be an important consideration in plant location, since similar effects will be experienced wherever the plant is located.

Similarly, with respect to the external disbenefits of the plant, given that a plant will be built, it is the differentials in these disbenefits with location that are important. Since an important consideration in the value of shoreline land is its scenic beauty, we expect there would be cases where substantial differences in these disbenefits between shoreline and non-shoreline locations might occur. This differential would have to be balanced against the added costs of the inland location which include not only additional pipe and pumping costs, but also additional transporting of equipment costs since present-day power generation equipment is so large that it must be transported by water. These costs will almost always dictate a shoreline location. As we have seen, shoreline locations do exist where the external cost of a plant can be kept small. But this example also indicates that almost anywhere a plant is suggested it will meet with local approval on grounds which, from the region's point of view, are a wash. Thus, local forces cannot be expected to generate opposition in proportion to the external disbenefits of the particular location.

It is of more than passing interest that, while the plant occupies some ten acres of property, Boston Edison purchased over 500 acres. This is, in part, a response to AEC regulations and, in part, provision for future additions. However, it suggests that public recreational use of most of this land could be complementary to the power generation proper. Florida Power and Light's installation at Turkey Point is an example. Boston Edison seems at least vaguely aware of this possibility and is providing for public access to the breakwaters, including a footbridge from one breakwater to the other. However, the possibility of more intensive recreational use of the upland property should be investigated. It is symptomatic of the political organization of the public's interest in the shoreline that the

Massachusetts Department of Natural Resources, which licenses the plant to eject wastes into the bay, has shown no interest in the public development for recreation of the land upon which the plant stands, despite the fact that this department contains the Forest and Parks Division which is charged with planning for outdoor recreation for the state.

APPENDIX C

STRATEGIES FOR HANDLING THE DEMAND FOR OIL IN NEW ENGLAND

C.1 Introduction

The purpose of this study is to assay possible development plans for oil processing and distribution in New England and the demands that these functions will place on the coastal zone. This study considers first the possibilities for a refinery in New England and then examines various distribution schemes with and without a refinery. It concludes:

a) A refinery in New England would result in very substantial savings in fuel costs to the region. If the entire savings were passed on to the consumer, the savings would have a present value of about five hundred million 1966 dollars at an inflation-free interest rate of five percent over the next forty years. That means the savings would be an equivalent to the increase in wealth which would result if each person in New England were given about $450.

b) The savings measure the amount that the region must be willing to pay in order to avoid such external costs of a refinery as the industrialization of a wilderness area, and air and water pollution. If the region values the external disbenefits at more than this figure for all possible locations of the refinery, then a New England refinery should not be built. If it values it at less than this figure, for at least some locations, then the net present value for these locations will be positive and the refinery should be built at that location which maximizes this net present value.

c) Clearly, the existence and location of this refinery is a very serious question and one in which non-market costs and benefits should play an important role if extremely serious misallocations are to be avoided. It does not appear that, at present, these effects are being properly weighed. Secondary or wash benefits appear to be geing given undue weight.

d) Given that a refinery is built, the most efficient distribution scheme, neglecting possible differentials in the frequency of oil spills, involves direct shipment via barges from the refinery to local distribution centers. If no refinery is built, the most efficient distribution scheme involves shipment via large product tankers to two transshipment terminals using monomoors - one in Boston's outer harbor and one in the Portland area. From these terminals oil would be transported via pipeline to Boston and Portland and via barges to outlying ports. Such a scheme is not only more efficient in terms of market costs than the present highly distributed net of terminals, but it probably has advantages with respect to oil pollution as well.

C.2 The Outlook for a Refinery

The primary sources of supply of crude oil to the Eastern U.S. are Venezuela, Libya and Nigeria. This crude oil currently arrives in foreign tankers of an average size of 100,000 deadweight tons and is fed primarily to the Delaware River refinery complex. Should refinery capacity be added to the New England area, there would be negligible change in crude oil transportation costs as the distance is approximately the same. The advent of petroleum reserves reaching the East Coast via the Northwest Passage though may change the picture. The additional 500 miles that specialized icebreaking tankers would travel to reach Delaware rather than to a New England refinery amounts to an additional cost of $0.24 per ton of crude oil. This cost is attributable to fuel, wages and capital costs. The specialized tankers capable of traversing the Arctic Ocean will be much less efficient than normal tankers in the open ocean. Use of an icebreaking tanker in open water incurs a high penalty because of its higher initial cost. A New England terminal offers a considerable incentive in view of the fact that oil companies anticipate in excess of 15,000 tons per day of Alaskan crude oil to be utilized on the East Coast.*

The size of the modern crude oil tankers is another reason for interest in the New England area. Future crude oil tankers will have displacements in excess of 250,000 tons. These ships draw 60 to 70 feet. There are no presently developed harbors on the U.S. East Coast

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*There is also the possibility that oil will be found in commercial quantities off the New England coast; however, we do not consider this eventuality explicitly in this report.

capable of handling these large ships.

The coast of Maine is one of the few places where drafts of 70 feet can be accommodated in sheltered areas. For example, Machias Bay could accommodate ships with a draft up to 100 feet in sheltered waters within one-quarter mile of the shore. Deep harbors such as these can be found in no other area on the East Coast.

Single point monomoor facilities can off-load petroleum at a rate of $0.08 per ton. The proximity of a Maine refinery to the off-load site means that crude oil could reach the refinery buffer storage tanks for a cost of not more than $0.10 per ton. The cost for supply of the same ton of crude oil to a Delaware River refinery is approximately $0.64 per ton since the refineries are about fifty miles from water deep enough to accommodate the tankers.

Table C.1 shows savings in initial crude oil delivery costs for foreign and Alaskan crude oil when new refinery capacity is located in New England rather than in the Delaware refinery complex.

TABLE C.1

Differential Costs for Oil Shipment to Delaware River Area and Machiasport

Refinery Site	Transportation Differential		Offloading Cost		Differential Cost	
	Foreign	Alaskan	Foreign	Alaskan	Foreign	Alaskan
Delaware River	0	$.24	$.64	$.64	$.64	$.88
Machiasport	0	0	.10	.10	.10	.10
			Savings -------		$.54	$.78

This shows that a crude oil transportation cost saving of $0.54 cents per ton of foreign crude oil and $0.78 per ton of Alaskan crude oil is realizable for new East Coast refinery capacity located in Maine rather than in Delaware. These savings are before product distribution and must be combined with differentials in the cost of distribution of the refined product before total differentials in transportation costs can be determined.

The average refinery unit processes about 100,000 barrels of crude oil per day. This is equivalent to approximately 5 million tons of product per year. As shown in Table C.2, New England demand can be expressed in terms of required refinery units.

TABLE C.2

Projected Refinery Units Needed

Year	1966	1980	2000
Product Demand tons/year	26,000,000	34,000,000	50,000,000
Refinery Units Needed to Meet Demand	5.2	6.8	10

It is assumed that existing refinery capacity in the Delaware River area is capable of supplying approximately six of the "refinery unit," or about 30 M tons/year. By 1972, refinery operations at Machiasport could become a reality. This initial refinery could be expected to supply all northern New England regional product demands except Boston, Portsmouth and Salem. Therefore, the new crude oil supplies could justify even more capacity in New England. Table C.3 presents the value of savings resulting from consumer proximity to the refinery; i.e., a short run for an intracoastal tanker is shown. Future refineries might also be located in the New England area as the need for refineries to supply New York, New Jersey and Connecticut increases. This growth rate is not currently available. The possible savings in distribution costs are given in Table C.3, assuming that only enough capacity to serve New England north of Cape Cod is constructed. The product tanker rates for distributing petroleum products are computed from typical costs for short tanker runs given by the Maritime Administration. In the next section, a more detailed analysis of alternative distribution schemes is given.

TABLE C.3

Harbor	Distance from Machias	Distance from Phila.	Distance Differential Miles	Products Tanker Size and Cost per ton mile	Year	Petroleum Throughput tons	Annual Savings in 1966 Dols.
Bucksport	124	552	428	37,500 DWT @ $.0009	1966	1,497,000	$1,025,000
				69,800 DWT @ $.0006	1980	1,975,000	1,014,000
				114,700 DWT @ $.0005	2000	2,935,000	1,256,000
Searsport	135	541	406	37,500 DWT	1966	637,000	$ 414,000
				69,800 DWT	1980	843,000	410,000
				114,700 DWT	2000	1,250,000	507,500
Portland	158	485	327	37,500 DWT	1966	4,000,000	$2,100,000
				69,800	1980	5,290,000	2,076,000
				114,700 DWT	2000	7,850,000	2,567,000
Portsmouth	203	458	255	37,500 DWT	1966	1,600,000	$ 653,000
				69,800 DWT	1980	2,110,000	646,000
				114,700 DWT	2000	3,140,000	801,000
Salem	326	436	200	37,500 DWT	1966	945,000	$ 302,000
				69,800 DWT	1980	1,249,000	300,000
				114,700 DWT	2000	1,855,000	371,000
Boston	239	436	197	37,500 DWT	1966	17,000,000	$5,360,000
				69,800 DWT	1980	22,500,000	5,320,000
				114,000 DWT	2000	33,400,000	6,580,000

In short, it appears that foreign oil can be refined and distributed in New England for about one dollar per ton less than it would cost to do the refining in the Delaware River complex. If Alaskan oil is used, this differential rises to $1.25/per year. Further, the Delaware River refineries are presently operating near capacity, thus additional capability will have to be built.

We therefore expect the oil companies to attempt to meet future New England demands with New England refineries whether or not Alaskan oil is available and whether or not a free trade zone is established. We expect, therefore, the oil companies to be desirous of constructing a minimum of two 100,000 barrel/day refinery units by 1980 in New England and a maximum of 8, if present Delaware capacity is transferred to serving other locations. By the year 2000, we expect them to have plans for a minimum of five and a maximum of 11. The most recent proposal, that of Atlantic World Ports, called for prompt construction of a 300,000 barrel per day unit. Under our assumption, the projected net present value of the savings, namely, the one dollar per ton over the next 40 years, which would result with New England refining in 1966 dollars at 5% is $540,000,000 and at 8% $430,000,000. That is, each man, woman and child in New England would have to put aside about $450 now to make up the differential in heating costs over the next 40 years.

C.3 Nonmarket Considerations

Existence of such large savings does not necessarily imply that a refinery should be built in New England. If the region is willing to pay this amount to avoid the external disbenefits of a refinery located anywhere in New England, then it should not be built. Further, there is some evidence that the region does place a high value on the detrimental aspects of a refinery. Attempts to build a refinery in the Narragansett Bay area in the middle fifties were frustrated by local opposition to such an installation. On the other hand, if nonmarket considerations are going to rule against a refinery, then the last section implies they must be very large indeed, and thus deserve considerable study. It is not clear that such study is taking place.

Given that a refinery is to be built somewhere, then one must weigh locational differentials in these nonmarket effects in deciding where to place the refinery.

In this respect, the two leading contenders for the location of, at least, the first New England refinery complex present an interesting and important problem in nonmarket effects.

The most commonly suggested location is Machias Bay. Machias Bay is the easternmost embayment in the mainland U.S.A. located some 40 miles from the Canadian border and 210 miles northeast of Boston. Machias Bay has over 100 feet of sheltered water less than a one-quarter mile from shore with immediate access to open water. The area is almost completely undeveloped. The peninsula upon which the proposed refinery would stand, Point of Main, contains only four houses. Three organizations have expressed interest in Machias Bay. The original proposal emanated from Occidental Petroleum. However, it was tied to the establishment of a free trade zone and a change in the import quotas. Atlantic-Richfield has bought options to lease several thousand acres and has not tied their offer to a change in the oil import laws. Recently, Atlantic World Ports has applied for oil import quotas and announced plans to build a refinery in Machiasport.

Another location which is receiving increasing attention is Casco Bay, specifically Long Island, three miles off Portland. Long Island contains about 400 acres and can accommodate drafts to 70 feet. Long Island already contains a 600,000 bbl underground oil storage facility on a 181-acre trace formerly owned by the Navy. King Resources, an oil importing concern, recently bought the site and has announced plans to build an eight billion bbl storage facility. A storage facility of this size without a refinery is pointless. Therefore, we can be sure that King Resources has a refinery in mind. King's plans have generated considerable opposition among the island's 300 year-round residents and local citizen's groups have brought suit against the City Council, who in June, 1969, rezoned the area from residential to industrial. At present, the matter is unresolved and King has indicated it will not proceed with any construction until the issue is decided.

The choice between these two locations* should be

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*We do not intend to imply that these are the only two possible alternatives. Maine is uniquely blessed with sheltered deep water. Other possibilities include Muscongus Sound and Penobscot Bay.

based on economics in the wide sense. That is, is it more consistent with the region's values to locate a refinery in a remote, almost wilderness, area in which very few people presently live, even though this choice would result in a critical modification of an entire scenic area, or to locate the plant on a residential island abutting an area which is presently rather highly industrialized (Portland already handles 20 millions of tons of oil per year), even though this would result in severe dislocation of the present residents and the further scenic deterioration of an area, which while no longer as beautiful as Machiasport serves many more visitors than Machias Bay?

We suggest that this locational problem deserves the most thorough kind of cost-benefit analysis for we can be sure of at least two things:

1) The location of this refinery will have an irreversible impact on the future development of the Maine coast; and

2) The unaided private market cannot be expected to pick that location which is most consistent with the values of the citizens of Maine and of the entire New England region not only because of the externalities involved, but because in a project of this size the developer can use parochial benefits to coerce not only a local community but an entire state. Further, competitive forces aren't really operative in this situation. Whoever builds the first refinery will have a monopoly over the region which it can expect to enjoy for many years.

The profits that the refineries can extract in this situation are simply transfer payments from the consumer to the refiner. Based upon these profits, the developer will find it easy to buy off all but the most determined organized opposition to the location he chooses in his private interest, whatever the merits of that location. Most of the present proposals involve 15% of gross profits to the state of Maine and 10% of gross profits to the other New England states. It will take a tough-minded legislator indeed to say that taxing oil users in this manner is not preferable to forcing the refiner to lower his prices instead.

There is no alternative to competent investigation by a public agency of the costs and benefits of all the various locations from a regionwide point of view and to tight public control of the resulting monopoly. We see no evidence that such investigation is taking place. In fact, we feel that the Maine agencies involved are placing too much emphasis on parochial benefits, which will occur wherever the refinery is located and thus are not a function of location. Further, it appears that the State of Maine is not driving as hard a bargain with potential builders as it might, in part because of over-counting of parochial benefits and in part because of the relative ease with which public funds can be raised through the refinery's monopoly powers.

In short, if there was ever a situation where detailed cost-benefit analysis should be applied to a coastal zone development, the problem of discovering that location, if any, for a New England refinery, which is most consistent with the values of all of New England, is such a situation. Needless to say, in the time frame of the present study any attempt at such analysis would have been irresponsible.

C.4 Distribution Policies for New England Oil

C.4.1 Introduction

This section surveys some of the economics of the distribution of the refined petroleum products to New England. It seems clear that the bulk of this distribution will continue to be by water. The following three questions then arise:

1) Should the product tankers service directly the six or seven ports which presently receive significant quantities of oil?

2) Should the product tankers ship only to a major transshipment terminal whereupon distribution takes place by barge?

3) If a refinery is built in New England, should product tankers be used at all?

Taborga (   ) has shown that the trade-off between the economies of scale associated with a small number of very large transshipment terminals and the added distance and transshipment costs associated with intermediate terminals implies that the typical regional development distributional pattern will be:

a) A phase in which there is a large and growing number of small terminals, each demand center being served by an associated terminal.

b) A more developed phase in which the economies of scale associated with transshipment begin to operate and indicate initial consolidation of sets of the individual terminals into large transshipment terminals which serve subregions.

c) A mature phase in which, if the economies of scale warrant, this consolidation process continues until the entire region is served by a single transshipment terminal. This process appears to be well advanced in the Western Europe-Bantry Bay, Ireland situation.

In this context, the question then becomes one of determining the degree to which New England has progressed through this sequence.

C.4.2 Assumptions

For the purposes of this study, demand is referred to as total tons of oil products without making any effort at disaggregation. The reasons behind this assumption are:

a) Determination of marine terminal characteristics and size is dependent on total throughput,

b) Demand by product for the New England area is not readily available,

c) The differences in specific gravity of different products can be disregarded in a general survey of the type being attempted here, given the preponderance of fuel oils.

The rate of increase of oil-products demand will be assumed to be approximately 2 per cent per year. This assumption is based on a study made by Arthur D. Little, Inc., in 1964-65.* The relatively small growth rate reflects the increasing share projected for nuclear plants in the power generation of the region.

Using 1967 as a base year, the following table gives the relative and absolute values of demand.

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*"Projective Economic Studies of New England."

TABLE C.4

Petroleum Demand by State

	Demand (1967) (tons)	Per Cent
New Hampshire	2,414,000	8.0
Maine	4,050,000	13.4
Massachusetts	22,120,000	73.3
Vermont	1,510,000	5.3
Total	30,094,000	100.0

The demographic patterns of the four states considered have been assumed stable; in other words, relative growth will not exist among them. This assumption is equivalent to saying that the spatial distribution of demand will not suffer significant variations in the time span considered by the study and that all net increases of demand will always be "allocated" in the same proportion to each state.

The main ports to be considered as potential locations for oil terminals are Machiasport, Penobscot River, Searsport and Portland in Maine, Portsmouth in New Hampshire, and Boston and Salem in Massachusetts.

Table C.5 shows marine distances between all locations considered.

TABLE C.5

Distances between New England Ports
(Nautical Miles)

	Pen. River	Searsport	Portland	P'tsmouth	Salem	Boston	Machiasport
Penobscot River	--	13.3	104.0	137.5	164.0	178.3	127.2
Searsport	13.3	--	90.6	124.3	151.0	165.0	114.0
Portland	104.0	90.6	--	50.8	83.5	97.8	146.0
Portsmouth	137.5	124.3	50.8	--	46.7	61.2	177.3
Salem	164.0	151.0	83.5	46.7	--	21.4	195.6
Boston	178.3	165.0	97.8	61.2	21.4	--	207.8
Machiasport	127.2	114.0	146.8	177.3	195.6	207.8	--

With respect to terminal technology, only monomooring systems will be considered. Earlier studies have shown monomooring to be the most cost-effective mooring system in the New England context.

The costs assumed as typical for all terminals are shown in Table C.6.

TABLE C.6

Construction and Operating Costs of Terminals

Number of Berths	Monomoor Cost	Underwater Pipeline Cost
1	$1,800,000	$1,500,000
2	$1,800,000 x 2	$ 700,000
3	$1,800,000 x 3	$ 700,000
4	$1,800,000 x 4	$ 900,000

Tank Farm on Shoreline = $18.00/Ton of Storage

Operating Costs:

Number of Berths	Tank Farm Crew Cost/Year	Line Running Launches (Deprec + Operating)/Year
1	$150,000	$150,000
2	$210,000	$150,000
3	$260,000	$150,000
4	$290,000	$300,000

The summary of unit costs above assumes similar conditions in all locations to be studied. This assumption should be modified to reflect an individual analysis of each situation if the type of methodology presented here were actually to be applied.

We have based our analysis on use of 69,800 deadweight ton product tankers throughout the life of the system. A more detailed analysis would entail predicting the growth in ship size through the life of the system or, better yet, employing expected value analysis as described in Chapter II, and postulating a distribution of product tanker sizes throughout the life of the system.

Distribution can be attempted by means of either pipelines or some form of maritime transportation. A pipeline in general has the disadvantage of little flexibility, since it cannot respond to the changes in optimal distribution strategies which occur with the growth and consolidation of a regional economy. Furthermore, the New England coast is concave. This implies that sea distances are shorter than land distances. But maritime transportation is generally competitive with pipelines over the same distances. The possibility of submarine pipelines does not seem an advisable alternative either, since the savings in distances are more than offset by the higher cost for materials and construction of the pipeline and by the operational complications associated with floating pumping stations along the pipeline.

With these facts in mind, our emphasis has been placed on marine transportation. The question then becomes one of deciding whether to ship from the refineries with product tankers directly to the shoreside distribution points or to transfer from the product tankers at a limited number of major terminals, using barges to supply the shoreside distribution points not served by the major terminals. The costs of transshipment must be balanced against the higher utilization of capital afforded by the barge system.

The barge costs cited are based on seagoing barges which are pushed rather than pulled by the towboat. Pushing has the advantage that the towboat-barge combination operates as one hull with consequent savings in power due to lowered wave resistance. It also is a more maneuverable and basically less hazardous system than towing. However, it should be noted that the pushing of barges in open sea conditions is barely the state of the art. However, the technological problems remaining appear far from insuperable.*

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*The problem of the coupling of towboats and barges in high seas conditions has not been properly researched yet, mainly on account of lack of visible need for it. It is hoped that this study will make apparent the current importance of such research.

Figures C.1 through C.3 show operational and cost characteristics of a pushed barge system.

C.4.3 Specific Cases

We have chosen to study three alternative major New England oil distribution systems:

I. A Distributed System. This system employs direct shipment via product tankers from the refinery to terminals at

Penobscot River	
Searsport	Maine
Portland	
Portsmouth	New Hampshire
Boston	Massachusetts
Salem	

II. System Employing Primary Consolidation. Here product tankers service Portland and Boston only and further distribution is by barge.

III. Complete Consolidation. Here all transshipment is handled from a single major terminal.

Two possibilities are considered under alternative III.

a) Tankers arrive at Boston only. This alternative corresponds to a minimum distribution cost configuration as can be seen by multiplying entries in the matrix of distances (Table D.5) times the demand at the destination and adding over each row. Boston has the least ton miles to be distributed with this arrangement.

b) The main terminal is in Machiasport, Maine.

As we shall see, analysis of this last alternative allows us to make the statement that, if a refinery is built in New England, all distribution should take place in barges directly from the refinery.

In all cases, inland distribution is treated as a parameter not having any impact on the comparison of alternatives being attempted.

The areas of influence for each port are as follows (as shown by 1967 data):

Portsmouth: Handles 66% of demand in New Hampshire.

Portland: Handles 100% of demand in Vermont, 34% of demand in New Hampshire and 57% of demand in Maine.

Penobscot River: Handles 30.5% of demand in Maine.

Searsport: Handles 12.5% of demand in Maine.

Salem: Handles 5% of demand in Massachusetts.

Boston: Handles 95% of demand in Massachusetts.

C.4.4 Summary of Evaluation Results

A comparison of alternatives is made on the basis of minimum present value costs to serve the demand shown in Table C.4 with this demand escalated at 2% per year.

Each alternative has four main items, berths and storage at the terminals, and barges and towboats, if transshipment is required (as in b and c). The present value calculations have been made for interest rates of 5% and 8%. 1970 U.S. dollars have been used throughout. Ten knots average speed has been used for barges and towboats.

Case I. Distributed System

TABLE C.7

Throughput at Each Terminal (millions of tons)

Ports	1970	1985	2000
Penobscot River	1.31	1.76	2.37
Searsport	0.53	0.71	0.95
Portland	4.91	6.61	8.89
Portsmouth	1.69	2.28	3.06
Salem	1.17	1.58	2.13
Boston	22.23	30.20	40.62

TABLE C.8

Arrival Rates (Ships/Month at Each Terminal)

Port	1970	1985	1990
		Year	
Penobscot River	1.37	1.84	2.48
Searsport	0.55	0.74	0.99
Portland	5.11	6.88	9.25
Portsmouth	1.76	2.37	3.18
Salem	1.22	1.64	2.21
Boston	23.20	31.20	42.00

C.4.5 Summary of Costs of Distributed System (Case I)

In the distributed system no transshipment is required and we must concern ourselves with terminals only. Table C.7 gives the annual operating costs and the present value costs for the terminals to service a distributed system in New England.

TABLE C.9

Yearly Costs and Total Present Value Cost for Terminals

	Yearly Cost			Total Present Value Cost	
Terminal	1970	1985	2000	Int. Rate 5%	Int. Rate 8%
	Thousands of Dollars			Dollars	
A*	935	935	950	15.32×10^6	11.4×10^6
Boston	2,627	3,122	3,425	48.40×10^6	36.46×10^6
Portland	1,529	1,529	1,800	27.03×10^6	18.76×10^6
Total present value costs for 4 Case A terminals, Boston and Portland				134.71×10^6	100.82×10^6

*Terminal A stands for any of the following terminals: Penobscot River, Searsport, Portsmouth, Salem.

Primary Consolidation (Case II)

In Case II the tanker terminals are built only at Boston and Portland. Boston serves Massachusetts and Portland the rest of the region. Existing tanker berths and tank farms would be used as barge berths.

TABLE C.10

Arrival Rates Ships/Month at Each Terminal

Port	Year 1970	Year 1985	Year 2000
Portland	8.79	11.83	15.90
Boston	24.42	32.84	44.21

TABLE C.11

Costs for Primary Consolidation System

	Annual Cost (Millions of Dollars) 1970	1985	2000	Total Present Value Cost (Dollars) Int. Rate 5%	Int. Rate 8%
Fleet	2.364	2.952	3.638	$46.75x10^6$	$35.20x10^6$
Boston Terminal	2.627	3.122	3.425	$48.75x10^6$	$36.46x10^6$
Portland Terminal	1.529	1.529	1.800	$25.03x10^6$	$18.76c10^6$
and the total present value costs are:				$120.53x10^6$	$90.42x10^6$

Final Consolidation (Case III)

For both Cases I and II the same total rate of arrivals applies. As in Case II existing tank farms and tanker berths are used as barge berths at an opportunity cost of zero.

TABLE C.12

Arrival Rates Ships/Month

	Year		
	1970	1985	1990
Boston or Machias	33.21	44.67	60.11

TABLE C.13

Case III Annual and Present Value Costs

	Annual Cost (Millions of Dollars)			Total Present Value Cost (Dollars)	
	1970	1985	2000	Int. Rate 5%	Int. Rate 8%
Fleet c1)	3.846	4.055	4.587	$64.50x10^6$	$49.60x10^6$
Fleet c2)	6.990	7.420	7.980	$114.30x10^6$	$86.42x10^6$
Terminal	2.720	3.247	3.683	$49.90x10^6$	$38.78x10^6$

TABLE C.14

Total Present Value Costs for Terminals at Boston and Machias

Case IIIa)	5% Interest	8% Interest
(Boston)	$114.40x10^6$	$88.38x10^6$

Total Yearly Cost in 1970 = $6,566,000

Case IIIb)	5% Interest	8% Interest
(Machias)	$164.20x10^6$	$125.20x10^6$

Given the remoteness of Machiasport with respect to the principal comsumption centers, the cost of using it as a transshipment center is prohibitive because of distribution costs alone. This situation is removed if IIIb) corresponds to the distribution problem associated to a refinery center in Machiasport. In such a case, costs of storage and tanker berths at the terminal are part of the F.O.B. price of the oil products at the refinery center.

Thus, we are avoiding a transshipment by placing a processing plant at the transshipment point and, therefore, (and only if we do so) the cost of the terminal should not be added to obtain the total of IIIb). The only cost in this case would be the fleet costs associated to the distribution operations. This alternative we have labeled IIIbR.

TABLE C.15

Case IIIbR. Present Value Costs

CaseIIIbR	5% Interest ($)	8% Interest ($)
(With refinery center)	114.30×10^6	86.42×10^6

TABLE C.16

Cost Summary

	Total Annual Cost in 1970 (millions of dollars)	Total Present Value Cost ($) 5%	8%
I	7.896	134.88×10^6	101.02×10^6
II	6.520	120.18×10^6	90.02×10^6
IIIa)	6.566	114.40×10^6	88.38×10^6
IIIb)	9.710	164.20×10^6	125.20×10^6
IIIbR	6.990	114.30×10^6	86.42×10^6

In summary, New England is approximately at the stage at which final consolidation of its oil distribution system should take place. If refined products continue to be shipped into the region from Delaware Bay, then the region should be seriously considering the construction of one or two transshipment terminals with subsequent distribution by barge. The cost difference we have indicated between one regionwide terminal in Boston and a pair of terminals in Boston and Portland is not large and the decision between these two alternatives should undoubtedly depend on factors we have left out of the analysis, such as externalities implied by transshipment terminals, differentials in frequency of oil spills, etc.

If a refinery is built in New England, even at a location as remote from the demand centers as Machiasport, the fact that alternative IIIbR is cheaper than alternatives II and IIIa indicates that no transshipment should take place and distribution should be via barge direct from the refinery.

Notice that IIIbR is not the predicted present value distribution costs associated with a refinery at Machiasport, but the costs of moving the oil from the Delaware River through Machiasport, deleting transshipment costs. II and IIIa are also based on oil originating in Delaware. Hence, the comparison is consistent. If the oil was actually processed in Machiasport, the costs of both systems would be reduced by the product tanker costs from Delaware to New England and the costs of II and IIIa increased by the product tanker costs from Machiasport to the shoreside or transshipment terminal, respectively. Hence, we can be sure that direct shipment from a refinery at Machiasport is indicated. Since Machiasport is the New England refinery location most remote from the demand centers, this conclusion will hold a fortiori for any other possible location. In short, if a refinery is built, it would serve as the final consolidation terminal.

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