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The Recreation Benefits of Water Quality Improvements

Analysis of Day Trips in an Urban Setting

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THE RECREATION BENEFITS OF WATER QUALITY IMPROVEMENT: ANALYSIS OF DAY TRIPS IN AN URBAN SETTING

by

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ABSTRACT

Considerable past work has attempted to estimate the recreational benefits which might accrue from water quality improvements. The theoretical underpinnings of this work, however, are becoming increasingly suspect. This report explores demand models, new to recreation analysis, which are based on site characteristics and individual preferences to estimate benefit measured by consumer's surplus.

The empirical findings of this study are based on a structured survey of 467 representative households in the Boston SMSA. Our focus was specifically day trips to a system of Boston area beaches, but considerable additional data on willingness-to-pay, substitution between sites and activities, water quality perception and general recreation behavior was developed as well. The reader will find an extensive review of the post-war literature on recreation economics and water quality benefits.

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I. INTRODUCTION AND SUMMARY

Recent years have seen a substantial increase in water-based recreation at the same time the nation's rivers and lakes are becoming seriously degraded. In response to the increasing water pollution, Public Law 92-500, the 1972 Amendments to the Federal Water Pollution Control Act was enacted. This law established as a national goal "water quality which provides for the protection and propogation of fish, shellfish and wildlife, and provides for recreation in and on the water..." To help meet this objective, $18 billion has been appropriated for municipal treatment works, and consumer price increases from 1-5% are expected to support the required industrial treatment. The Act represents one of the largest public works programs ever instituted in the United States.

Objectives

This study is an inquiry into how water quality affects the recreation objectives of the Act. While national estimates of the recreation benefits stemming from water quality improvement could help evaluate and administer the nation's water pollution control program, such estimates were not the objective of this project.*

Our purpose is more limited. The principal objective was to advance the methodology for estimating the recreation benefits of water quality enhancement. To further this objective, data on the recreation habits of.a sample of 467 Boston area households was collected in the course of the project.

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*One author [1] suggests over three-quarters of all water quality benefits lie in recreation.

NOTE: Throughout this report references are cited by number corresponding to alphabetical chapter bibliographies. A general bibliography is presented in Appendix IV.

The research also explores some of the fringes of recreation economics as well. We examine the importance of factors such as setting, facilities and maintenance in site choice. The distinction between benefits from water quality as a merit good are drawn and to a lesser extent quantified. Recreationists' perception of water quality is compared with objective measures of water quality and we investigate the potential for reducing the many dimensions which define "water quality" to a smaller number of composite measures.

Methods in Brief

Three general phases complete the study. The first concentrated on reviewing the recreation literature, and developing the theory of multi-site demand models. Based on the models selected for testing, a survey instrument was prepared, pre-tested and revised. A set of fresh and salt water sites within a one day visit from the Boston SMSA (about 50 miles) was delimited at this point in the project. The sites were chosen to represent most of the daily recreation trips, and to be close substitutes in terms of the activities available.

Data collection comprised the second phase. First, beach and water quality characteristics for the system of sites were compiled. From on-site visits, a beach quality catalog was completed by the research team and water samples were taken and analyzed. During December, the questionnaire was administered to a representative sample of 467 Boston SMSA households.* Nonresponse was eliminated by random replacement (Section IV.3 details this procedure). Some respondents choose not to answer certain questions, so the "no answer" response was analysed separately for each questionnaire item.

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*Originally the survey was to be conducted the first week in September, immediately after the Labor Day closing of the outdoor recreation "season." Clearance by OMB of the survey instrument took much longer than expected, which necessitated the late starting date. Details of the sample design, and a discussion of the biases which may have been introduced by the delay are contained in Chapter IV.

The last phase of the project involved extensive statistical analysis of the survey data. First, the household characteristics were tabulated to check for possible, obvious biases in the sample--none were found. Then direct questions, concerning response to water quality changes were analyzed. Next, simple tabulations of visits, activities, and willingness-to-pay were made. At the same time, a factor analysis of water quality parameters was performed to examine the grouping of the variables across sites and develop composite water quality indices. These in hand, we examined the correlation between perceived water quality and actual water quality. The third step in the analysis involved estimating (via multiple regression) the determinants of willingness-to-pay and recreation behavior. Finally, two multi-site models were specified and estimated.

Outline of the Report

Seven more chapters complete the main body of this report. The next chapter deals with some important background issues--the definition and measurement of recreation activities and recreation benefits. Five measures of recreation benefits are reviewed and four are rejected. We choose to focus on a benefit measure based on consumer surplus and demand analysis and its correlary in survey research, willingness-to-pay. The chapter reviews the major post-war literature on demand analysis applied to recreation research, and codifies this research into a consistent theoretical framework.

Chapter III presents the theory of multiple site models and describes the problems of empirically estimating these models and retrieving consumer surplus measures from their parameters. It also reviews two previous multiple site models found in the economics literature.

Chapter IV focuses on the mechanics of the study. It describes how the network of sites was constructed, and reviews the characteristics of the system. The water quality parameters used in the study are described and justified, and a factor analysis reduction of the water quality variables is explored. This part of the report closes with a discussion of the household survey and a comparison of the sample with Boston SMSA population.

The principle empirical findings of the study are presented in Chapters V, VI and VII. Chapter V first analyzes the response to the direct questions concerning the determinants of recreation behavior and finds that water quality is not among the most important determinants of either site choice or demand. Chapter V continues to examine the accuracy of subjective ratings of water quality; to a large degree, public perceptions of water quality do not match the objective measurements.

Chapter VI considers willingness-to-pay: its magnitude, variation across subgroups of the sample and determinants. Despite the finding of Chapter V that recreationists neither seem to consider water quality in site choice, nor are able to perceive objective water quality, respondents of all income groups, races and educational levels are willing to pay between $20 and $26 per family per year for water quality maintenance and improvements. For the Boston SMSA, this may represent from $17 to $28 million per year.

Empirical estimation of multiple site recreation demand models is the subject of Chapter VII. After reviewing the data and aggregate determinants of recreation behavior, an "abstract site" model is estimated. Water quality seems to affect site choice but not the number of visits once a site is chosen. Because this model is not directly grounded in utility theory, retrieving consumer measures from its parameters is not possible. A second multiple site model which has this property is specified, but attempts to estimate it were constrained by the project budget.

Four appendices complete the report:

Appendix I: Site Facility Inventory Form

Appendix II: Water Quality Sampling

Appendix III: The Survey Instrument

Appendix IV: General Bibliography.

CITED REFERENCES

1. Department of the Interior, Federal Water Pollution Control Administration, "Delaware Estuary Comprehensive Study: Preliminary Report and Findings," July 1966, Chapter 6.

II. RECREATION AND MEASURES OF ITS BENEFITS

> "The greatest gift is the power to estimate correctly the value of things."
>
> Francois de la Rochefaucauld
> Maxims, No. 224. Cited in
> Resources [28].

The problem of "estimating correctly" the value of recreation benefits, probably unknown to Rochefoucauld when he penned this statement, requires three distinct steps:

(1) an exact definition of "recreation;"

(2) a metric for quantifying the recreation activities; and

(3) a transformation of the quantity of recreation into dollar terms.

Each of these steps must further be relevant to the particular problems of estimating benefits from water quality enhancement.

This chapter clarifies each of these three parts of benefit quantification to form a suitable background for the methodological and empirical chapters which follow. The first section below delimits the recreation experience, and discusses the recreation activities relevant to water quality improvements. The second section develops measures to help quantify the recreation experience. The last section reviews the metrics available for transforming recreation experience into benefit measures.

1. The Recreation Experience

Recreation benefits can be delimited in the context of Jordening's [16] taxonomy of water pollution abatement benefits. He lists four categories:

(1) human health;

(2) production;

(3) aesthetic; and

(4) ecological.

Our interest lies in the third category. According to the taxonomy, this category includes water-based and water-oriented recreation, property values and general aesthetic appreciation of water. Our focus is limited to water-based and water-oriented activities.*

Specific activity and duration define the types of recreation to be considered under this research. Outdoor recreational activities can be divided into three types:

(1) those which depend on the existence of water (water-based);

(2) those which may be enhanced by proximity to water (water-enhanced); and

(3) all others.

Our concern is with the first two. Table II-1 presents a participation analysis for these types of activities. Because of the importance of water quality characteristics to water-based recreation, these were the primary focus of the research. However, gross levels of water pollution may affect the enjoyment of water-enhanced activities, so picnicking, walking for pleasure and bicycling were included in the analysis. Camping and hunting were eliminated because, as explained below, their duration is typically longer than these other activities.

This list of activities does not complete the specification of recreation under study. The duration of the recreation experience must be addressed. Clawson and Knetsch [7] divide the recreation experience into five parts: (1) anticipation; (2) travel to the site; (3) on-site experiences; (4) travel from the site; and (5) recollection.

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*Property value changes are often used as a measure of benefits, but then direct recreation and aesthetics are confused, and possibly double counted. Section II.3, below, considers other empirical and theoretic shortcomings of the property value approach.

Table II-1

Water-Related Outdoor Recreation Activities

Activity[1]	% Population Participating[2]	1970 Number of Recreation Days x 10^6	(% of total)[2]
Water-Based			
Swimming	46	1722	(14.2)
Fishing (fresh & salt water)	29	562	(4.5)
Boating (including canoeing, sailing. waterskiing)	24	422	(3.5)
Subtotal	--	2706	(22.3)
Water-Enhanced			
Picnicking	49	542	(4.5)
Walking for pleasure (including hiking, nature walks)	48	2235	(18.4)
Bicycling			
Camping	21	397	(3.3)
Hunting	12	217	(1.8)
Subtotal	--	3391	(28.0)
Total Water-Related	--	6097	(50.3)
Total All Outdoor Recreation	--	12,126	(100.0)

SOURCE: (1) Following N.L. Nemerow, H. Sumitano, & R.C. Faro, [24].

(2) Bureau of Outdoor Recreation, [5].

The experience itself (Phases 2-4) is taken to be as the recreation activity. This approach is consistent with past studies which include the cost of travel as part of the price of recreation.

The content of the on-site portion of the recreation activity constitutes the major component of the recreation activity. In order to derive appropriate benefit measures, it is important to understand clearly the content of this phase, as many previous studies confuse the purpose of the on-site recreational activity. Fishing provides a good example of this confusion. The utility of fishing is not necessarily related to the number of fish caught. Benefit measures based on the market value of fish or increased angling success may not reflect the qualities sought in a fishing experience.* A noted outdoor writer, Ernest Schwiebert [29] describes the experience:

> "Many satisfying things are to be found along trout water, and on hard pressed streams they help compensate for lack of fish ... (the angler) remembers not only the fish taken or lost but also the little things along the stream. I remember the scores of ducks and geese on a Yellowstone pond, the intense blue of the Wyoming sky on those crisp September mornings and the doe and fawn that crossed a Boardman riffle at twilight in Michigan... A scoreless evening in the Catskills was saved by the balmy pine scented wind that swept down the Valley just at dusk. All of these things mean as much as the fishing itself."

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*Studies using these and other benefit measures are reviewed in Section II.3, below.

2. Quantifying the Recreation Experience

Traditional metrics for quantifying the magnitude of a recreation experience are the user-day* or visit.** Theoretically at least, the number of days per visit and the number of visits must be ascertained simultaneously to derive user-days. Travel costs represent a fixed cost of the activity, and must be amortized over a sufficiently large number of days of the activity for the marginal value of the activity to exceed its cost.

The anticipation phase of the recreation experience offers a method for separating the interactions between the number of visits and the duration of the visit. Essentially three broad classes of recreational activities exist: day trips, weekend trips (two day or three with Monday holidays), and longer vacation trips. These differ in terms of the associated anticipation required, and hence may be considered as essentially distinct although possibly similar, classes of recreation. Then the unit of recreational activity is defined separately for each class of recreation. For day trips the unit is, equivalently, the number of trips or the number of days. For weekend trips the appropriate unit is the number of trips. For longer, vacation-related, recreation activities, the number of user-days should be examined.

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*Defined by D.E. Hawkins & B.S. Tindall, [15], as (page 2), "The presence of one or more persons on lands or waters, generally recognized as providing outdoor recreation, for continuous, intermittent or simultaneous periods of time totalling twelve hours."

**Defined by Bureau of Outdoor Recreation [6], as (pages 1-4), "A visit by one individual to a recreation development or area for recreation purposes during a reasonable portion or all of a 24-hour period. It is assumed that the average person participates in 2.5 activities during an average visit to a recreational area. Therefore, 2.5 activity occasions equal one recreation day."

We chose to focus on one day trips. This focus eliminates the theoretic quandary and empirical difficulties of estimating simultaneously the number and duration of visits. The possible travel distance for one-day trips conveniently establishes a universe of sites for sampling and survey. These low anticipation level recreation activities will tend to eliminate any cultural differences in the desire or ability to plan. Day trips from the Boston Area offer suitable variability in water quality and site characteristics to assess the recreational benefits of water quality enhancement. This limitation permits careful analysis of urban water quality problems where the recreation benefits of water pollution abatement appear to be greatest.

The major liability in this approach is the elimination of certain wilderness settings where the sensitivity of demand to water quality may be large. This limitation of the study necessitated dropping camping and hunting, together comprising about 5% of total recreation days, from the research.

Our empirical analysis, therefore, relies on visits as the principal measure of the amount of recreation. The specific definition of "visits" used in this analysis is discussed in Section IV.4 below.

3. The Monetary Value of the Recreation Experience

The post-war literature on recreation benefit measures offers six alternative approaches for transforming the recreation demand into dollar values:

(1) gross expenditure;

(2) market value of fishing;

(3) income multiplier;

(4) property values;

(5) willingness-to-pay interview; and

(6) demand function (consumer surplus).

This section of the report reviews these methods and concludes by arguing that consumer surplus estimates derived from demand functions are the most appropriate measure for estimating recreation benefits. The chapters below use this measure, and its survey research equivalent--willingness-to-pay--to estimate recreation benefits of water quality improvements.

The Gross Expenditure Method

Much of the early literature, particularly, favored this approach, whereby the benefits of recreation activity are measures by the total costs incurred per recreationist, including travel and on-site costs. The justification for this approach is that these costs must represent at least a lower bound to the value which the recreationist places on the activity for otherwise, if it was worth less than these costs to him, he would not undertake it. This argument is valid as far as it goes, but it does not go far enough. By ignoring consumers' surplus, the gross expenditure method underestimates the value to the recreationist of his activities. The understatement of benefits is serious because, when it comes to calculating the net benefits of providing recreation facilities, the only net benefits are the transfer payment component of costs, which may be zero even for projects which yield positive net benefits when the latter are correctly measured. The gross expenditure approach also leads to the well-known paradoxes that, when the elasticity of demand is equal to or less than unity, an increase in the quantity of recreation activity leads to a reduction in benefit as measured by gross expenditure, which is contrary to economic intuition. Note also that the use of the gross expenditure approach begs the question of how to predict recreation activity at a site.

Market Value of Fish

Crutchfield [8] argues the value of a sport fishery equals to the market value of the fish it produced. This work incited of a plethora of studies in agricultural and forestry experimental stations throughout the country to estimate the market value trout, salmon, bass, pickerel, pike, walleyes and so on. The principal shortcomings of this method is that it excludes the benefits of the recreation experience which are not related to filled keels. The most obvious demonstration of this omission is the extra money and time the angler expends beyond that required to obtain the fish from the market.

A related methodology, explored principally by Stevens [30 & 31] and Stovener [32], relates the benefits of water quality enhancement to angler success. This procedure relaxes the assumption that the value of the experience equals the market value of the fish caught, but still insists that the value is proportional to the number of fish caught. Where water quality improvements lead to step changes in the type of fishing, the number of fish caught of the preferred type may be significant. But this is an effect of shifting the demand curves, not moving along it. The most important step changes occur where water quality improvements lead to: (1) establishment of sport fisheries where previously no fishing existed, (2) replacement of carp and other coarse fish by bass and other warmwater species, and (3) introduction of salmonoid habitat.

The Income Multiplier Method

In some studies it is quite common to find an estimate of the increase in local income and production induced by an expansion in recreation activity, usually calculated via a local input-output matrix. (Recent examples are Reiling [28] , and Stoevener [32]). However, these estimates can be misleading. The existence of indirect benefits depends largely on local conditions. The method also assumes that there are locally underutilized resources (i.e., the shadow price of the activity or commodity is zero). If the resources used as inputs to the increased local production would otherwise have been fully employed, there is no net gain in the flow of goods and services available to society, merely a transfer from one location to another. These estimates of induced local income growth are valid only insofar as the regional distribution of income is a separate component of the objective function, and long run federal policies designed to encourage regional development are at least arguable.

The Property Value Method

This technique is widely used although, in our opinion, it suffers from certain fundamental conceptual flaws. The pioneering studies were done by Knetsch [17], also David [10 & 11], Berger [21], Darling [9], and Dornbusch [14]. Almost all of these studies apply the "cross-section" model of land value-benefit assessment; however, the Dornbusch study applies a "time series" model. The analytical issue can be seen most clearly by considering the cross-section model, which we discuss first.

The central concept in this approach is the "rent-gradient function" which expresses rent or property value at each location as a function of its distance from a central feature, in this case a water body. It is a well-documented empirical fact that, at least within a certain radius, this function has a negative slope i.e., land values are higher nearer to the water's edge. But what inference can be drawn from these data?

First, we mention some well-known objections to the land value method: it omits the benefits accruing to residents outside the area, and there may be some double-counting if estimates of recreation benefits obtained by this technique are added to estimates obtained by some other technique, such as willingness-to-pay interviews, a common practice (Berger, [21], Darling [9], Dornbusch [14]). However, the objection which we emphasize is that the land value method represents an illegitimate application of partial equilibrium analysis.

Our argument is in two steps:
(i) As usually conducted, the land value method of analysis is not an accurate measure of the change in land values because it ignores the impact on rents outside the vicinity of the area. The conventional analysis proceeds as follows (for the case of *ex post facto* analysis of a change in water quality). One observes that land values in the vicinity of the water body are higher than those at some distance from it, and that they decline with the distance. One calculates the aggregate differential in land values within some (often arbitrary) radius of the water body, over the level of land values outside that radius, and uses this differential as a measure of the benefits from the change in water quality. This would be a reasonable procedure on the assumption that (a) land values in the vicinity of the water body were at approximately the same level prior to the change as the

level of rents observed outside the vicinity of the water-body after the change, and (b) land values outside the vicinity of the water-body were approximately the same before the change as after the change. It is very plausible that the second assumption is false.(Berger [21] for example, recognizes this, but proceeds to ignore it.)

Intuitively, one would expect land outside the vicinity of the water-body to become relatively less attractive after the change in water quality and, therefore, to fall in price. This assumes a fixed population of residents in the overall area. In practice, this assumption might be violated because of population increase. If the population of the overall urban area grew exogenously (i.e., from natural causes) the growth in the demand for housing might keep rents outside the vicinity of the water-body at their pre-quality change level. But clearly, this is an irrelevant phenomenon and the appropriate datum for measuring the benefits of the quality change is the pattern of rents which would have occurred in the absence of the population increase. If the population increase is endogenous (i.e., it is due solely to the water quality change which causes a flow of immigrants to the urban area), then it may be that rents outside the vicinity of the water body are stabilized at their pre-quality change levels and the total rent differential measured in the manner described above is an accurate index of the change in land values <u>within a general equilibrium setting</u>. However, we doubt whether the hypothesis of endogenous population growth is applicable to most of the pollution abatement situations studied in the literature.

In the context of cross-section studies, the rent-equation is misleading for analogous reasons; rents may fall in areas outside of the environmentally improved region and, in consequence, rise less in that region than the regression equation predicts. The circumstances in which this will happen can be described more rigorously in the context of a theoretical model of location and rent determination which is outside the scope of this study.

The Dornbusch methodology is slightly different, but it suffers from analogous defects. In that study the change in property values in areas where water quality has improved is regressed on distance from the site and it is shown that the increase is greater close to the site. But, in order for this finding to be meaningful, it would have to be shown that the increase in land values would not have occurred anyway even without the improvement in site quality, say, because of an exogenous change in population or income. In other words, the Dornbusch study does not show how much of the increase is due to the change in water quality. (One way to do this would be to undertake a similar study of the change in property values at sites whose water quality had not changed and to use these as a control group.) Moreover, the Dornbusch study does not consider whether property values have fallen, or grown less rapidly than would otherwise have happened, at sites outside the vicinity of the water body.

This first argument is quite widely recognized. Our second point is more often overlooked

(ii) Even assuming that one could accurately measure the change in equilibrium rent gradients of all points in the area occasioned by the change in water quality, this still would provide no basis for measuring the social value of the improvement in environmental quality. This can best be seen by considering the following hypothetical, but not unreasonable, example. Consider a community of 100 persons living in a town which contains, at one end, a polluted lake, and, at the other, a flat plain. There is space for 100 homes both on the lakeshore and on the plain but, since the lake is polluted, everyone prefers to live on the plain. Land rents on the plain are $100 per acre (or per dwelling--it makes no difference); on the lakeshore rents are only $10 per acre, since no one likes to live there. Now the quality of water in the lake is drastically improved and everybody wishes to live on the lakeshore. Everybody moves to the lakeshore, nobody lives on the plain and it so happend (there is no reason why this could not happen) that rents are now $100 per acre on the lakeshore and only $10 per acre on the plain.

The end result is that after the quality change there is no net change in total rent payments. Yet we would certainly wish to argue that there has been an increase in social welfare. (This can be proved by revealed preference arguments: people would not have moved home if they were not thereby better off.) Thus, it is seen that the change in aggregate rent payments, even when full allowance is made for rent changes outside the environmentally improved area, provide no indication of the change in social welfare. The reason why this is so is identical to the reason why gross expenditure does not provide an adequate measure of the social value of consumption (i.e., willingness-to-pay). In both contexts the omission of consumers' surplus understates benefits. Furthermore, in the present context, where there are shifts in the demand curve, as well as in the supply curve, the change in expenditure bears absolutely no relation to the change in the area under the demand curve. Without knowing the demand curve explicitly one can infer nothing from data on the change in equilibrium price and quantity.

Strotz [33] has recommended measuring the social benefit from environmental quality improvements by summing the absolute values of changes in rents at each point. However, it can be shown that this result derives from the peculiar assumption of his model and has no general validity. Also Lindsay [20] has recently attempted to prove that the aggregate change in land values is an adequate measure of social benefit of environmental quality changes, using a linear programming assignment model. However, the proof is based on certain quite limited assumptions and is not generally valid.

The Willingness-to-Pay Interview Method

This technique was first applied by Davis [12], and subsequently, by Knetsch and Davis [19], Berger [21], Dornbusch [14], and Brown and Hammack [3], and others. In principal, this technique is conceptually sound; however, its empirical value depends entirely on the method of application and the degree of confidence that one can have in the veracity (and accuracy) of interviewer responses. Knetsch and David [24] cite reasons for believing that respondents may both overstate and understate their true willingness-to-pay.

Since the method offers a correlate to consumer surplus derived from demand function, willingness-to-pay questions were implemented and analyzed from the survey research effort.

The Demand Function Approach

Hotelling [23] first suggested this approach in 1949 in a now famous letter to A.E. Demeray, then Associate Director to the National Park Service. During the post-war bidding for chunks of an expanding federal budget, the park service decided a "monetary evaluation" of park service facilities might both assist their management and expand their budget. The park service asked ten of the nation's leading social scientists and economists to comment on the feasibility of such a study. The reviews were mixed and mostly forgotten, but Hotelling drew on the work of Jules Dupuit, an 18th century French engineer, who derived formulae for estimating the public benefits of bridges, roads and canals, to suggest:

> "Let concentric zones be defined around each park so that the cost of travel to the park from all points in one of these zones is approximately constant. The persons entering the park in a year, or a suitably chosen sample of them, are to be listed according to the zone from which they come. The fact that they come means that the service of the park is at least worth the cost, and this cost can probably be estimated with fair accuracy. If we assume that the benefits are the same no matter what the distance, we have, for those living near the park, a consumers' surplus consisting of the differences in transportation costs. The comparison of the cost of coming from a zone with the number of people who do come from it, together with a count of the population of the zone, enables us to plot one point for each zone on a demand curve for the service of the park. By a judicious process of fitting it should be possible to get a good enough approximation to this demand curve to provide, through integration, a measure of the consumers' surplus resulting from the availability of the park. It is this consumers' surplus (calculated by the above process with deduction for the cost of operating the park) which measures the benefits to the public in the particular year. This, of course, might be capitalized to give a capital value for the park, or the annual measure of benefit might be compared directly with the estimated annual benefits on the hypothesis that the park area was used for some alternate purpose."

The demand function approach has since been implemented somewhat inaccurately by Trice and Wood [34], and authoratively by Clawson and Knetsch [7]. Subsequently, it has been employed by Lerner [19], Ullman and Volk [35], Pankey and Johnston [25], Dearinger [13], and Brown [4], and extended by Merewitz [22], Stevens [30 & 31], Boyet and Tolley [2]. All of these formulations have been in the context of the demand for a single site. This approach may be summarized in the following equation:

$$V_i = F(P_i, Y_i) \qquad \ldots (1)$$

where V_i is the number of visits made to a recreation site by individual i (or by the inhabitants of county i), P_i is the cost of reaching the site (including travel cost) for individual i (or for a representative resident of county i) and Y_i is a scalar or vector of socioeconomic variables describing individual i (or describing the residents of county i including, usually, the county's population). In some early versions of the model, price was not entered as a variable but instead distance was used as a surrogate. Stevens [30 & 31] extended this model by adding an index of site quality to the explanatory variables. The particular index which he chose, angling success per day, is, as shown above, oddly an indirect measure of site quality.

Generally, demand is estimated for a single site without consideration for other sites, or all sites visited by the sample population are combined, and a single equation is estimated. The latter approach is essentially a "participation study" and is beyond the scope of this report. The former approach suffers from a significant short-coming, namely the so-called price dominance criteria.

The conventional procedure is to allocate recreation demand among some new site and the existing alternative sites according to a price dominance. Let P_i' by the cost to residents of county i of visiting the old sites, and P_i'' the cost of the new site. The implicit criterion is that (i) if $P_i'' > P_i'$, nobody from location i attends the new site while (ii) if $P_i'' < P_i'$ everybody from that place visits the new site, the total volume of attendance being $V_i'' = F(P_i'', Y_i)$. In case (i), there is the same volume of recreation as before the change, namely $V_i' = F(P_i', Y)$, and it is concentrated exclusively at the old sites. There is no economic gain from the quality change for the residents of the county. In case

(ii) nobody attends the old sites and the economic gain consists of the change in expenditures plus the change in consumers' surplus associated with the change in prices from P_i' to P_i''

This analysis can be justified in two ways: (1) if the new site and the old sites offer exactly the same bundle of characteristics and are identical in every way except for price/distance, then the price dominance criterion should be valid; and (2) if the new site offers a somewhat different bundle of characteristics from those offered by the old sites, in other ways besides price/distance, then the use of the price dominance criterion involves an assumption that recreationists choices are made only on the basis of price and are independent of other site characteristics.

This empirical hypothesis was not substantiated. It was tested by estimating appropriate demand functions for individual sites with other site characteristics besides price included among the explanatory variables. Once these models have been estimated, the hypothesis becomes a null hypothesis that non-price related coefficients are zero. As seen in Chapter 5, this is not the case.

One way around these difficulties is to estimate simultaneously demand functions for a system of competing sites which form the universe of sites visited by the sample population. Substitutions between sites are then explicitly estimated. Although certain conceptual and empirical difficulties arise with these models this is essentially the approach taken here. The handful of recreation studies which employ this technique, and a theoretical development of an improved multi-site model are contained in Chapter III, below.

Having the demand equation, three procedures have been used to estimate benefits, and two of these are incorrect. The most simple is the dollar value of a user day. This is used by the federal government in water resource project evaluation but omits the consumer surplus enjoyed by some users.

The second way of estimating benefits calculates the revenue which could be gained by a non-discriminating monopolist. But, of course, only a discriminating monopolist can price away all of the "willingness-to-pay" for a good, so the result is inaccurate in a manner similar to the first approach.

Consumer surplus measures the total willingness-to-pay for the recreation activity. If the prevailing price is $5 per unit, and a certain individual is just indifferent to consumption at a price of $15, he enjoys a consumer surplus of $10. Ignoring income effects, consumers' surplus equals the revenue which could be obtained by a discriminating monopolist. In 1949, Hotelling pointed out this fact, but it has not been considered by most recreation economists. Consumer surplus is the theoretically correct measure of benefit, and is the one used in this study.

One further note on benefit measurement from demand equations is appropriate. Total benefit can be measured as the area under the demand curve up to the prevailing price. If the good in question was traded in a competitive market, the costs (producer revenue) could be subtracted to estimate net benefits. However, recreation is not such a good and the public sectors' market share position depresses the private market and prices. Hence the costs are not the appropriate ones to consider. Basically, the problem comes down to determining the costs, both institutional and economic, required to achieve both adequate water quality for recreation, and increased recreation itself. (As seen below, the costs of additional facilities needed for recreation may be large.) These costs could then be weighed against the benefits to select the appropriate public policy. However, these costs, as are the benefits, are highly sensitive to local conditions. Therefore, neither net benefit calculations, nor nationwide benefit calculations are appropriate for the research at hand. Instead, this study focuses on total benefit measured by consumer surplus, and ignores the costs of providing that recreation.

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III. MULTIPLE SITE MODELS FOR RECREATION DEMAND

Multiple site demand models offer one way to eliminate the shortcomings of the more common single equation models reviewed above. This chapter surveys the existing literature on systems of demand equations for recreation sites and sets down some principles for developing alternative demand models. Some of these alternative models have been applied to our data on recreation behavior in the Boston area, and the results are described in Chapter VII; others impose extremely heavy computational requirements and for this reason were not estimated.

The basic objective here is to model the demand for a set of alternative recreation sites in such a way as to (i) allow for the possibility of inter-site substitution, (ii) make explicit the relationship between environmental quality conditions and inter-site demands, and (iii) permit the explicit calculation of consumer's surplus measures of benefits from changes in site costs or environmental conditions. As the next section shows, these objectives have not been achieved by the existing multi-site models in the literature. Section 2 sketches some non-stochastic models which do meet the objectives. Finally, Section 3 discusses some stochastic choice models which could be used for this purpose, and which explicitly allow for the phenomenon of zero visitation rates for many of the sites as well.

1. The Multiple Site Demand Models in the Literature

To the best of our knowledge there have been only a handful of recreation studies which attempt to estimate simultaneously the demand for a network of competing recreation sites. These studies may be divided into two groups. The first group may be called allocation simulation studies, and the second, system demand models.

The goal of the first type of model is to simulate the allocation of recreationists among a set of alternative sites using some reasonable criterion, but one not necessarily based on a statistically validated behavioral model of recreation choices. For example, in one version of the Tadros-Kalter [10,11] model recreationists are allocated among alternative sites on the basis of a travel distance minimization subject to constraints on site capacity, time and money expended on travel, and exogenous zonal recreation demands. The model is solved using conventional linear programming techniques. In another version of the Tadros-Kalter model, the same constraints are used but the allocation criterion becomes one of maximizing visitor day satisfaction, measured by the sum of attendance at each site from each origin zone weighted by an index of the attractiveness of the site to recreationists originating in each zone. The attractiveness index turns out to be the available recreation area at each site divided by its distance to each origin. Hence the attractiveness maximization criterion is similar to the travel distance minimization criterion of the first model.

The Ellis model [5 & 6] assigns recreationists to alternative sites through a combination of travel cost/distance minimization and site attractiveness. Total attendance at each site is proportional to an index of its attractiveness. Subject to this constraint on total attendance, site attendance by zone of origin is determined by cost minimization using network theory techniques. The site attractiveness index is a weighted sum of sub-indices of site capacity, the quality of water resources at the site, and the quality of the site's scenic setting. The weighting of these sub-indices is not based on empirical estimates of behavioral choices but appears to derive at least partly from calibration studies designed to assure that the model provides a reasonable facimile of observed recreation patterns.

It must be emphasized that neither the Tadros-Kalter models nor the Ellis model can claim to be grounded in observed recreation behavior. Both the cost minimization criteria and site attractiveness indices employed are assumptions which, although plausible, were not validated by acceptable statistical techniques.

Finally, there is a recent paper by Bàron and Scheckler [1] which, though formally different from the Ellis study in its use of network analysis, is a similar combination of travel distance minimization plus an allowance for the differential attractiveness of alternative sites. As in the Ellis study, this differential attractiveness index derives from ad hoc calibration procedures rather than a verifiable model of recreationists' choice behavior. None of these models, therefore, is of direct interest to us since we wish to use formal statistical procedures to estimate the behavioral relationships. In addition, none of these models is based on utility theory and, therefore, the apparatus of consumers' surplus analysis cannot be applied to derive benefit estimates.

Now consider two system demand models, both intended for statistical estimation and both at least tenuously related to utility maximization theory. These are the models of Burt and Brewer [3] and Cicchetti *et al* [4]. The two models are, in fact, virtually identical and differ only in the estimation techniques used to implement them. Both involve the estimation of a set of n equations (assuming n recreation sites):

$$\begin{aligned} x_{1t} &= f_1[P_{1t}, P_{2t} \dots P_{nt}, Y_t] \\ &\vdots \\ x_{nt} &= f_n[P_{1t}, P_{2t} \dots P_{nt}, Y_t] \end{aligned} \qquad \dots (1)$$

where x_{it} is the number of visits to site i by individual t, $(P_{1t} \dots P_{nt})$ is a vector of the prices of the sites (travel costs, etc.) for this individual, and Y_t is a scalar or vector of such variables as his household income. The system (1) is a natural extension of the single site demand functions

$$\begin{aligned} x_{1t} &= f_1[P_{1t}, Y_t] \\ &\vdots \\ x_{nt} &= f_n[P_{nt}, Y_t] \end{aligned} \qquad \dots (2)$$

which were discussed in Chapter II.

The Burt-Brewer and Cicchetti *et al* implementations of (1) are somewhat unsatisfactory for the present study on two counts, one concerning the use of the model to obtain estimates of consumer's surplus and the other concerning the problem of how differing water quality conditions affect consumer's behavior. The first issue involves some technical aspects of the theory of consumer demand only summarized here. It is a fundamental theorem of consumer theory that if and only if a set of demand functions such as (1) satisfy certain conditions on their first partial derivatives there exists a unique underlying utility function. Moreover, under these conditions, it is possible to define and calculate measures of consumers' surplus for price changes. The conditions to which we refer are that the cross-price derivatives of the compensated demand functions be equal. In terms of the ordinary demand functions--such as (1)--the conditions are that:

$$\frac{\partial x_i}{\partial P_i} + x_j \frac{\partial x_i}{\partial Y} = \frac{\partial x_j}{\partial P_i} + x_i \frac{\partial x_j}{\partial Y} \qquad \forall\ i,j. \qquad \ldots (3)$$

The conditions are sometimes, but mistakenly, taken to require that the cross-price derivatives of the ordinary function be equal--that is:

$$\frac{\partial x_i}{\partial P_j} = \frac{\partial x_j}{\partial P_i} \qquad \forall\ i,j \qquad \ldots (4)$$

This in fact is what Burt-Brewer and Cicchetti, et al both do although for different reasons. Burt-Brewer [3] require the cross price derivatives to be equal under the assumption that "income elasticities among the outdoor recreation commodities are relatively close in magnitude," an assumption they state but do not support or test (although it seems likely for their application). Note that these are the exact conditions when an unconstrained maximization problem is posed (Hotelling showed this in 1932). Hence if total expenditure on recreation is small relative to total income, then these may be good approximations to the exact conditions.

Cicchetti et al [4] analyze the integrability conditions in great detail. They find small income elasticities of demand for downhill skiing (a surprising result which they attribute to the use of income data aggregated to the county level), but that the cross price demand derivatives are not equal. They use a quasi-Bayesian approach to reconcile the two sets of price elasticities (prior information that the cross price terms were equal, sample information that they are not) and proceeds as though the integrability conditions were satisfied. Thus, they set out to estimate (1) as a set of linear functions in the variables $P_1 \ldots P_n$ and Y, and impose the constraint that the coefficient of P_j in the i^{th} equation be the same as the coefficient of P_i in the j^{th} equation.

Although it is erroneous, the condition (4) has a certain convenience in that it causes the integral of the area under the demand curves (1) between two price vectors to be path independent--in the same way that the condition (3) causes the integral of the area under the compensated demand curves to be path independent. However, this is of dubious value because the relevant area for measuring consumer's surplus is the area under the compensated demand function and not that under the ordinary demand curve. It is true that the latter area may be considered an approximation to the former but as we shall show in the next section, it is possible to adopt certain alternative specifications of (1) from which an exact measure of consumer's surplus can be obtained with relative ease.*

Note that when recreation demand is estimated separately from demand for all goods, the Y of equation (3) is total expenditures on recreation, not income. But neither Burt-Brewer nor Cicchetti et al estimate the cross elasticities of demand (between sites) with respect to total expenditures or recreation. Chapter VII returns to this point.

So far, the discussion has considered only exact measures of consumers' surplus. Willig [13] has shown that when the income (or in our case, recreation expenditure) is small, the errors in ignoring the cross elasticity term of (3) are also usually small. Rather than rely on this empirical serendipity, however, we choose to specify, in Chapter VI, a model where exact measures are possible.

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*It would be possible to test this hypothesis using, for example, a likelihood ratio test, although neither Burt-Brewer nor Cicchetti et al bother to do this.

The second point concerning the Burt-Brewer and Cicchetti et al studies is less theoretical and is more directly concerned with the practical value for water quality analysis of the demand systems which they estimate. The equations in (1) do not contain environmental quality variables as explicit arguments. The fact that site conditions may differ and that this may influence recreationists' behavior is only acknowledged implicitly in these models. That is, if the sites do not differ, or if they differ but the differences have no influence on recreationists' behavior, then we would expect all the site demand functions to have the same own price coefficient and, presumably zero cross-price derivatives; in effect we are back to the single-equation general demand functions represented by equation (1) in Section II-3. Otherwise, if the coefficients of different equations are different, we may infer that this is because site conditions differ and that these differences affect recreationists' behavior, they are relatively unilluminating: they do not tell us which aspect of the site conditions has the most effect on recreation choices and whether this effect is large or small. They do not directly enable us to predict the consequences of changes in site conditions on recreation demand patterns, still less to measure the benefits of these changes in a theoretically rigorous manner. One way to achieve the first objective, if not the second, is to regress certain of the fitted coefficients--for example the own price conditions--on variables measuring site quality. Burt-Brewer and Cicchetti do not do this, but it is an eminently feasible procedure.* However, instead of doing this, we prefer to bring the environmental quality variables directly into the demand equations; in the next section we outline several methods for doing this.

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*This procedure has been followed in a different context by Parks & Barten [8] who were estimating a set of commodity demand equations separately for several countries. Parks & Barten wished to discover if consumer demand patterns were influences by demographic structure and they investigated this by regressing the coefficients of the fitted equations for each country on certain demographic variables.

2. System Demand Models--Nonstochastic Choice

We begin by elaborating on the remarks of the previous section that to obtain exact measures of consumers' surplus from the Burt-Brewer [3] or Cicchetti et al [4] type model a different specification of (1) which is more easily reconciled with the theory of consumer behavior must be adopted. It is true that there are relatively few analytical demand functions which automatically satisfy the conditions (3) and which, therefore, can be traced back to an underlying utility function. Nevertheless, there are some functions with this property and they have been used in studies of consumer behavior over the last decade with some success. Among the most convenient and widely used is the LINEAR EXPENDITURE SYSTEM, which actually was introduced by Stone [9] more than twenty years ago.

Before describing this model and showing how it can be used to model the demand for a set of recreation sites, it may be useful to review some basic elements of consumer demand theory. This will also enable us to clarify the distinction between the models discussed in this section and those to be discussed in the next section. Assume that the individual consumer has a utility function defined over his comsumptions of n commodities, $u(x_1 \ldots x_n)$ and that he arranges his purchases as though he were solving the constrained maximization problem:

$$\underset{x}{\text{maximize}} \quad u(x) \quad \text{subject to } \Sigma P_i x_i = Y, \quad x_i \geq 0 \qquad \ldots(5)$$

The Kuhn-Tucker theory introduces the multiplier λ to derive the first-order conditions for the stationarily of (5) as

$$\partial u/\partial x_i - \lambda P_i \leq 0 \qquad i=1\ldots n \qquad \ldots (6a)$$

$$\Sigma P_i x_i = Y \qquad \ldots (6b)$$

$$x_i \geq 0 \quad \lambda \geq 0 \qquad \ldots (6c)$$

$$x_i \cdot [\partial u/\partial x_i - \lambda P_i] = 0 \qquad i=1\ldots n \qquad \ldots (6d)$$

The implication of (6d) is that if we knew that all n goods were always going to be consumed in some quantity the n demand functions could be obtained from the solution to the following equalities:

$$\partial u/\partial x_i - \lambda P_i = 0 \qquad i=1\ldots n \qquad \ldots (7a)$$

$$\Sigma P_i x_i = Y \qquad \ldots (7b)$$

which are a subset of the equations in (6). Alternatively, if there were $m>n$ goods, but we knew that the same $(m-n)$ goods would never be consumed at any feasible prices and incomes, while the other n goods always would be consumed, then we could obtain the demand functions for the latter goods by solving (7); in effect we could ignore the prices of the $(m-n)$ goods which are never consumed. In practice, as we shall see, neither of these assumptions is satisfied: by no means all of the sites are visited by each recreationist nor, on the other hand, it is not necessarily true to say that if a person is not visiting certain sites now then he would never visit them. However, since it is vastly simpler to derive a set of demand functions from (7) than from (6) we shall assume throughout this section that (7) is the relevant set of equations for deriving a system of demand functions from a specialized utility function. The next section presents some demand models which are explicitly based on (6).

Return to the linear expenditure system. If we take as the consumers' utility function the following specific formula

$$u(x) = \sum_{i=1}^{n} b_i \log(x_i - c_i) \qquad \ldots (8)$$

with $\Sigma b_i = 1$, and solve the equation corresponding to (7), we obtain the following demand functions

$$x_i = c_i - \frac{b_i}{P_i} Y - \sum_{1}^{n} c_j P_j \qquad i=1\ldots n \qquad \ldots (9)$$

Direct differentiation of these equations will show that they satisfy condition (3). Moreover, an exact measure of the consumers' surplus when prices change from P_i^o to $P_i^!$ can easily be obtained from (8) and (9). It is given by:

$$C = \left[Y - \Sigma P_j^o c_j\right] \prod_{i=1}^{n} \left(\frac{P_i^!}{P_i^o}\right)^{b_i} - \left[Y - \Sigma P_i^! c_i\right] \qquad \ldots (10)$$

The utility function (8) is a simple translation of the Cobb-Douglas utility function.

$$u(x) = \Pi x_i^{b_i}, \quad \Sigma b_i = 1 \qquad \ldots (11)$$

The demand functions derived from the latter utility function are

$$x_i = \frac{b_i Y}{P_i} \qquad i=1\ldots n \qquad \ldots (12)$$

Thus, (11) and (12) can be regarded as limiting forms of (8) and (9) when all the c_j's are zero. The effect of this restriction on the c_j's is that there are no cross-price terms in the demand functions for individual goods.

The problem to be resolved is how to generalize the equations for the utility function such as (8) and (11) to deal with product quality as well as consumption quantities. The solution proposed is to make the parameters of the utility function themselves a function of commodity characteristics. This, in turn, has the effect of making the parameters of the demand curves a function of commodity characteristics. To see how this works introduce a set of variables Z_{ik}, i=1...n, k=1...m, representing the amount of characteristic k available at site i. Then, starting with the utility function (11), we postulate:

$$u(x,Z) = \Pi x_i^{b_i} \qquad \text{... (13)}$$
$$b_i = f_i[Z_{i1},...Z_{im}]$$

The resulting demand functions are, of course, the same as (12), with the functions $f_i(\cdot)$ substituted for the b_i's. However, this model is computationally inconvenient because we have to impose the restriction that $\Sigma f_i = 1$. In view of this, it is actually simpler if we work with the more general utility function (2) and make the c_i's functions of the commodity characteristics:

$$u(x,Z) = \Sigma b_i \log(x_i - c_i) \qquad \text{... (14)}$$
$$c_i = f_i[Z_{i1},...Z_{im}]$$

There is no theoretical basis for choosing a specific form of $f_i(\cdot)$; for example, we could have

$$c_i = W_{io} + \sum_k W_{ik} Z_{ik} \qquad \text{... (15a)}$$

or

$$c_i = W_{io} + \sum_k W_{ik} \log(z_{ik}), \qquad \text{... (15b)}$$

where $(W_{io}...W_{im})$ are unknown coefficients to be estimated along with b_i. However, it simplifies the computations greatly if we assume that

$$W_{ik} = W_k, \qquad i=1...n,\ k=1...m.$$

This assumption implies that, other things being equal, the effect of a change in a given characteristic--say turbidity--is the same for all sites. This does not necessarily mean that all sites are equally attractive, because site characteristics are likely to be different. Moveover, we have also left open the possibility that the b_i's and W_{io}'s are different across sites, so that even if all sites had exactly the same characteristics and the same prices, their demands could differ. With this assumption, the site demand functions implied by (14) and (15a) for the case of two characteristics are:

$$x_i = W_{io}+W_1Z_{i1}+W_2Z_{i2}-b_i\frac{Y}{P_i} - \sum_{j=1}^{n} b_iW_{jo}\frac{P_j}{P_i} - \sum_{j=1}^{n} b_iW_1Z_{j1}\frac{P_j}{P_i} - \sum_{j=1}^{n} b_iW_2Z_{j2}\frac{P_i}{P_i} \quad \ldots$$

$$i=1\ldots n \qquad \ldots (16)$$

A similar set of demand functions would result if we used (15b) instead of (15a). The estimation of these systems of equations is discussed in Chapter VI.

3. Stochastic System Demand Models

There are several stochastic choice models available in the literature which could be used. For example, the multinomial logit model assumes that the individual selects one of n alternatives--in this case recreation sites--so as to maximize an explicit utility function.* The observed output of this process is an nxl vector with (n-l) zero elements corresponding to the rejected alternative and one element containing the value "l" corresponding to the alternative which is chosen. Blackburn [2] independently developed a slightly more general model in which the output is an (nxl) vector containing (n-l) zeros as before and, in the row corresponding to the chosen alternative, the number of times the preferred alternative is actually chosen (consumed).

Both these models are restricted to situations in which only one alternative is chosen, and there is reason to believe that is not the case with the choice of recreation sites. It is, therefore, interesting to enquire whether a general stochastic choice model can be written in which an arbitrary number out of n alternatives is selected. Such a model could be based on the full set of Kuhn-Tucker conditions for utility maximization given the previous section. The method used makes some of the parameters of the utility function (and hence the demand function) stochastic variables. First, ignore the question of commodity quality, since it can be incorporated relatively easily along the same lines as in equations (15) above.

In order to allow for the case of zero consumption, the utility function (8) must be slightly altered to ensure a bounded derivative at the zero consumption point. As an example, the

*See Theil [12] and McFadden [7].

utility function could be

$$u(x) = \sum_{i=1}^{n} \tilde{b}_i \ln(1+x_i) \qquad \ldots (17)$$

where the $\tilde{b}_i$ are random variables, depending partly on the site characteristic Z_{ik}. Then (6) and (17) imply that the probability of an observed individual consumption pattern in which, say, the individual visits only the first m sites, the frequency of visitation being V_i, i=1...m, while V_i=0, i=m+1...n, is given by:

$$\Pr \left\{ \tilde{b}_i \; \frac{\sum_{j=1}^{m} \tilde{b}_j}{Y + \sum_{j=1}^{m} P_j} \quad \text{for all } i=m+1\ldots n \right.$$

$$\left. \text{AND} \quad \frac{\tilde{b}_i}{\sum_{j=1}^{m} \tilde{b}_j} = \frac{(1+V_i)P_j}{Y + \sum_{j=1}^{m} P_j} \quad \text{for all } i=1\ldots m \right\} \qquad \ldots (18)$$

If a suitable distribution can be assumed for the b_i's, we can write down the likelihood function based on (18) in closed form and apply maximum likelihood estimation techniques. However, it is clear that with (at least) 29 alternative sites the maximization of this likelihood function will be computationally infeasible. Therefore, the empirical work in Chapter VII relies on the non-stochastic system demand models described in the previous section.

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*The model would be feasible only with about 3-5 alternatives.

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IV. SITE AND HOUSEHOLD SAMPLE, SURVEY AND CHARACTERISTICS

Chapters II and III outlined our methodological approach for estimating the recreation benefits of water quality enhancement. This chapter describes the data used to implement these methodologies.

The data needed for these approaches includes:

(1) a network of recreation sites which are potential substitutes;

(2) data on the characteristics of the sites; and

(3) data on the number of visits by a representative individual to each of the sites.

A number of recreation studies were reviewed to obtain the requisite information from secondary material. These sources included:

- National Park Service
- Forest Service
- Bureau of Outdoor Recreation
- Corps of Engineers
- Bureau of Sports Fisheries and Wildlife
- Massachusetts Department of Natural Resources
- Boston Metropolitan District Commission
- Boston Redevelopment Authority
- Metropolitan Area Planning Council (Boston's Area A-95 agency)

None possessed the three requirements outlined above, so a data collection effort was mounted. This included:

- establishing a network of water-based recreation sites available for a one-day trip from the Boston SMSA;

- assembling water quality, cost and beach characteristics data on these sites; and
- surveying a representative sample of Boston SMSA households.

This chapter describes, in five parts, the data collection effort. First, a system of sites is presented. Then the site characteristics and water quality variables and data are discussed. This section includes a factor analysis designed to reduce the water quality variables to an analytically more manageable number. Next, the rationale and design of the household survey is presented. Finally, to set the stage for the empirical results contained in Chapters VI and VII, this chapter concludes with a discussion of alternate measures of attendance.

1. The Network of Sites

Delimitation of the geographic extent of the study is the initial step in defining a system of recreation sites for analysis. Ideally, all possible sites available for one-day trips from the Boston inner city would be included. Due to the lack of data on the recreational habits of Bostonians, a surrogate to visitation--distance--was arbitrarily employed to delimit the one-day trip region. This region is roughly bounded by the New Hampshire border to the north, the Cape Cod Canal to the sourth, Massachusetts Bay and the Atlantic Ocean to the east, and Lake Cochituate to the west. It is enclosed by a major circumferential highway, I-495, and lies within 40 miles of the Massachusetts State House.

Once the geographic extent of our study was defined it was necessary to inventory the recreation sites available in that area. One of the problems inherent in deriving an exhaustive water recreation survey from the Boston Metropolitan Area is the multiplicity of sites. Besides the ocean frontage, Boston is the locus of several rivers and their watersheds, and many natural lakes and ponds. Our first attempt at a water site inventory began with several good maps of the metropolitan area. It became apparent that the number of small, unmarked sites was large, and that we should direct our efforts elsewhere.

The Department of Natural Resources of the State of Massachusetts had conducted a state-wide open space survey in 1970* from which we culled the water-recreation sites for the towns within the study area. This inventory was supplemented by lists of the State of Massachusetts Metropolitan District Commission (MDC) beaches, beaches from the Trustees of Reservations, state parks and forests, and streams and ponds stocked by the Massachusetts Division of Fisheries and Game. This inventory included over 200 swimming sites, nearly 200 fishing sites, and about 70 boating sites for the metropolitan region. Table IV-1 presents the breakdown between types of sites.

Table IV-1

Analysis of Available Recreation Sites

Area	Number of: Towns	Sites	Number of Sites Offering: Swimming & Fishing	Boating
Inside Route 128	38	143	111	28
Remainder of Study Area	77	201	91	43
TOTAL	115	344	202	71

*Massachusetts Department of Natural Resources [13].

Such a large inventory presents several major problems for our methodology, however. The difficulty of analysis increases more than geometrically with the number of substitutable sites. In addition, the survey would be unwieldly with so many locations. Many of the sites are small, and used only by a very local constituent population; further, it is difficult to collect data on facilities, characteristics, and water quality from such a large number of sites. Because of these difficulties, the focus of our site inventory turned to a sample of sites in the study area which could account for a large proportion of the area's recreation. However, the site-specific visitation data required to delimit numerically the major sites is sparse. One source* was used for this purpose, and a set of eighteen major sites was developed. Our experience, however, suggested a number of important sites were not represented. The initial list was supplemented by major sites from the Massachusetts Department of Natural Resources open space inventory. This composite list was presented for review to a number of individuals and agencies familiar with and knowledgeable about recreation in Eastern Massachusetts. Reviewing agencies included:

Metropolitan District Commission

Metropolitan Area Planning Council

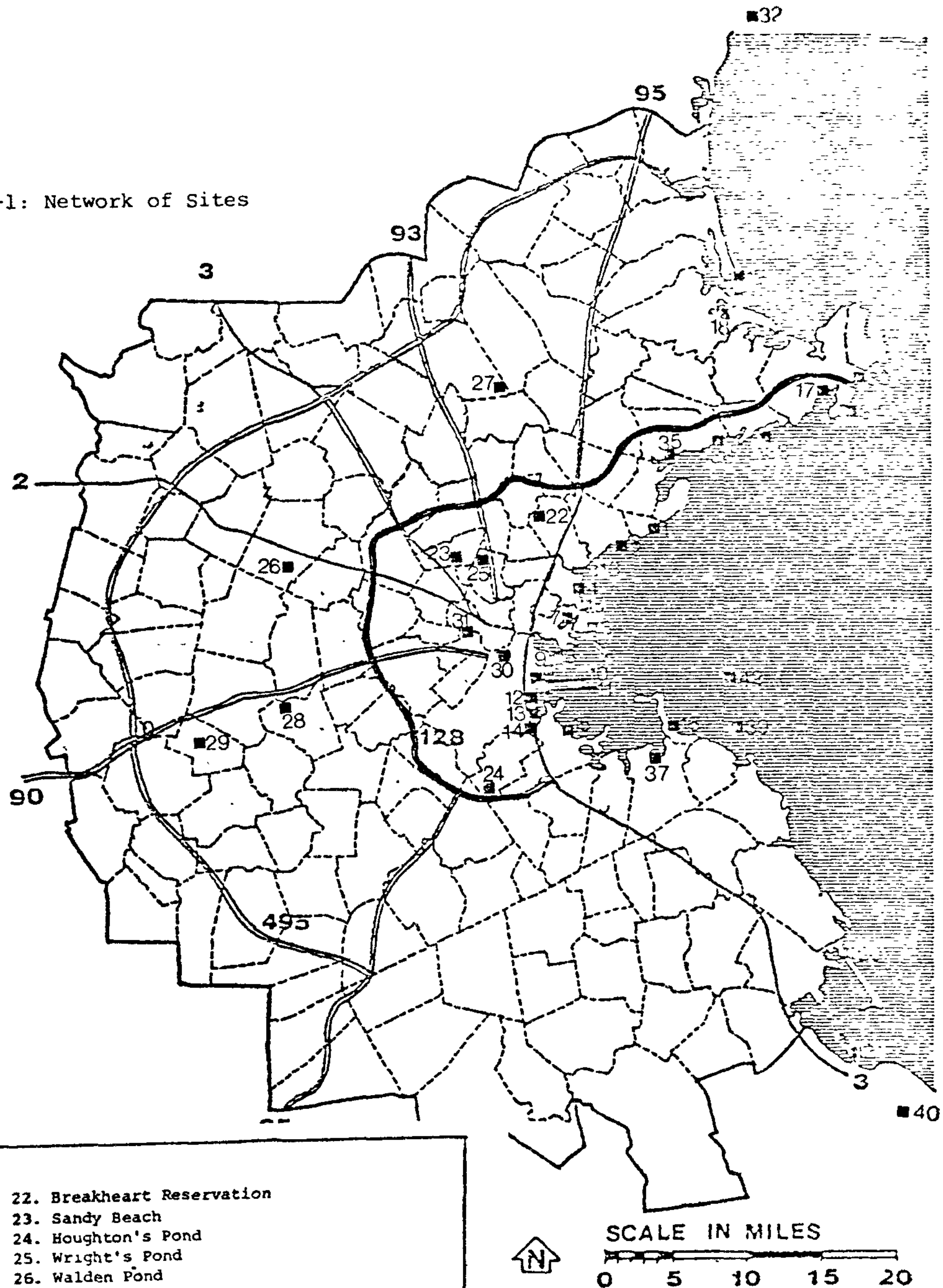
Massachusetts Department of Natural Resources

In addition, a private recreation planner with extensive experience in Eastern Massachusetts reviewed our list.

During the course of the survey, this list of 31 sites was supplemented by asking respondents what other sites they visited. Another 14 sites or generic places (i.e., Cape Cod Beaches, New Hampshire Lakes, etc.) were identified. The network of sites and the study area are depicted in Figure IV-1. These site numbers are used throughout the report to identify the sites.

*Metropolitan Area Planning Council [15].

Figure IV-1: Network of Sites



List of Sites

1. Kings Beach
2. Lynn Beach
3. Nahant Beach
4. Revere Beach
5. Short Beach
6. Winthrop Beach
7. Constitution Beach
8. Castle Island
9. Pleasure Bay
10. City Point
11. L & M Street Beaches
12. Carson Beach
13. Malibu Beach
14. Tenean Beach
15. Wollaston Beach
16. Nantasket Beach
17. Wingaersheek Beach
18. Crane's Beach
19. Plum Island
20. Duxbury Beach
21. White Horse Beach
22. Breakheart Reservation
23. Sandy Beach
24. Houghton's Pond
25. Wright's Pond
26. Walden Pond
27. Stearns Pond
28. Cochituate State Park
29. Hopkinton State Park
30. Esplanade/Storrow Lagoon
31. Charles River, between Weeks & Anderson Bridges
32. New Hampshire Beaches, Lakes & Parks
33. Good Harbor
34. Gloucester Beaches in General
35. Dane Street Beach
36. West Beach
37. Hingham Beach
38. Other North Shore Beaches
39. Other South Shore Beaches
40. Cape Cod Beaches
41. Lynch Park
42. Other Massachusetts Lakes & Ponds

■ - recreation site
= - interstate highway
— - major US or Mass. highways
--- - town boundary

The sites in this set are, with one exception (Crane's Beach, operated by the Trustees of Reservations and open to the public), public facilities. It is well-known by recreation management that the public provision of recreation facilities is subsidized, depresses the private market for recreation. For our analysis this is important only because the fees customarily paid are likely to be much lower than the marginal social benefits of the facility, and estimates of willingness-to-pay may, therefore, be biased downward. According to one study [13] of the 229,423 acres of recreation lands in Eastern Massachusetts, 46,551 acres, or 20.3%, are private. Private sites number 779 or 14.7% of the 5,318 sites in the region. Private ownership includes both profit and non-profit operations:

- private clubs
- Massachusetts Audubon Society
- Trustees of Reservations;
- Boy and Girl Scouts;
- YMCA and YWCA; and
- commercial recreation lands.

While there is significant incidence of private recreation in the area, not all of these operations are entirely supported from fees. Hence our estimates of willingness-to-pay may be understated.

2. Site Characteristic Variables

Site characteristics can be broadly divided into economic, beach quality related, and water quality related. Each of these groups are discussed separately below.

The site characteristics used in this study were culled out of the literature on recreation participation and demand. In particular, Myles [16], Aukerman [2], David [5], Holman & Bennet [10], and Gamble & Meglie [9], contributed to this effort. Throughout we have distinguished objective characteristics and perceived characteristics. Objective characteristics are those, like water temperature, which can be measured using known, accurate and reliable techniques. Perceived characteristics reflect how people believe the beach to be. The perception includes an assessment--possibly erroneous--of the objective characteristics, and a reaction to that assessment. No doubt, demand is more closely related to the perceived characteristics than the ones only a scientist can measure. And, in fact, the first step in our analysis tests whether or not perceived and objective characteristics mesh. Unless the two measures--objective and subjective--are collinear, inferences from the relationships between demand and objective water quality measures may be misleading.

The contrast between perceived and objective water quality has other interesting ramifications. Recall Clawson and Knetch's five phases of the recreation experience. Anticipation of a recreation experience sets the expectations for the site characteristics and activity content. Once on site, the perception of the site is matched against the anticipation, and this contrast forms the basis for recollection. In turn, that recollection, in large part, determines future anticipation of a similar experience and hence repeat demand. Equilibrium levels of demand should represent a reasonable matching of expectation and perception. Therefore, to the extent that only equilibrium demand is measured, inferences from objective measures to preferences will be valid.

Furthermore, any demand analysis can only address "iso-anticipation" activities. In other words, exogenous considerations--leisure time, family income, time of year, etc.--determine tradeoffs between day trips, weekend trips, and vacation trips, but within the anticipation classes, endogenous site characteristics, including travel cost and price, prevail. Secondly, demand surveys must be conducted in equilibrium conditions. Ideally, then, only users with prior knowledge of the site should be surveyed, perhaps only repeat users. Similarly, sites where relative changes in water quality have occurred should be omitted from the analysis. A brief investigation indicated that none of the sites in the sample had undergone notable changes in water quality during the last few years.

2.1 Economic Variables

These variables describe the costs incurred by the recreationist prior to the on-site phase of the activity. They include the costs of travel and entrance. Four variables were identified:

- o Entrance/parking fee
- o Travel time
- o Travel cost
- o Distance.

The first three of these were determined from the survey.

Entrance Fee: When your party goes to a beach you might have some expenses just to get onto the beach, such as parking or entrance fees. For each site, about how much are these expenses?

*Throughout the report, the particular question being analyzed is repeated in the main text to aid the reader. A copy of the complete survey instrument is contained in Appendix III.

Travel Time and Cost:

A. For each site you mentioned in Question 2 (A & B) above, how did you or your group get there?

a. walking	d. bus
b. bicycle	e. subway/streetcar
c. automobile	f. taxi
	b. other _________

B. About how long does it take to get there that way? (in minutes)

C. How much does it cost to get there? If by bus or subway or taxi, how much is the roundtrip fare? If by auto, what was the price of tolls? (the total cost for the visiting group)

Distance: Distance was calculated as a straightline Euclidean distance between the respondent's location and the site. This was computed by plotting all the sample points and all the sites on a large scale map. A quarter inch grid was overlaid and the coordinates recorded. The distance from respondent i to site j was computed from the formula:

$$d_{ij} = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}$$

where: $(x,y)_i$ = Cartesian coordinates of respondent i

$(x,y)_j$ = Cartesian coordinates of site j

and then scaled to miles.

Actual road milages are the best measure of distance, but because of the large number of respondent-site combinations in relation to the project budget, those computations were not possible. An alternative is to scale straightline distances according to the size of the road grid. It is easy to show that on a uniform grid the average distance equals about 20% more than the straightline distances. One could hypothesize a larger grid size as the distance from the center city increases, and scale the distance variable accordingly. Instead we chose to use, in the model specifications, the straightline distance squared as a surrogate for this phenomenon.

Table IV-2 presents the summary statistics for these variables.

Table IV-2

Economic Variables

Variable	Mean	Std.Dev.	Skewness	Kurtosis
Entrance/Parking Fee ($)	1.04	3.77	6.040	35.83
Travel Time (Minutes)	32.87	22.25	1.447	1.993
Travel Cost ($)	.65	1.10	2.441	4.897
Distance* (miles)	17.77	9.12	.557	-1.293

*This distance is the average distance from the sample points to the sites. It is not the distance traveled averaged over all individuals.

2.2 Beach Characteristic Variables

Four dimensions of beach quality were defined:

- o setting;
- o facilities;
- o quality; and
- o crowding.

Data on these characteristics were collected two ways. First, the sites known at the time of the survey were catalogued using the form contained in Appendix I. To reduce bias introduced by the personal perception of the researcher who visited the site, only two people were assigned this job. They inventoried together several beaches to insure comparable interpretations. Second, respondents were asked to rate the beach they attended most often according to beach quality, beach facilities and crowding. Quality and setting were lumped together because it was thought the two would not be distinguished by respondents.

Setting:

Setting was determined from the questionnaire in the following categories, in descending order toward less natural settings:

A. Surrounding Land Use
    1. Natural
    2. Agricultural
    3. Low Density Residential (1 & 2 family homes)
    4. High Density Residential (includes multi-family buildings)
    5. Commercial
    6. Industrial

Table IV-3 shows the distribution of these settings across sites.

Table IV-3

Site Setting

Setting	# of Sites	Percent
Natural	12	27.3
Agricultural	0	0
Low-Density Residential	13	29.5
High-Density Residential	1	2.6
Commercial	3	6.8
Industrial	3	6.8
Not Surveyed	12	27.3

Facilities:

Facilities--bathhouses, picnic tables, etc.--related to all water-oriented activities were inventoried. Initially we suspected sites could be distinguished according to activities available, but the facilities provided proved to be remarkably homogeneous across sites, so the objective measures of facilities were omitted from further analysis.

Of special interest to this study is our finding that facilities seem to be rather important to recreationists. Of 467 respondents, 24.5% mentioned the presence of either changing rooms or lifeguards as the most important determinant of characteristics toward their choice of site. Hence, if water quality is enhanced, additional capital and operating investments will be needed to obtain the potential recreational benefits. This point is further amplified by response to littering, pointed out below. Chapter V analyzes the results in greater detail.

Quality:

Objective measures of beach quality are difficult to define. Three were attempted. The first related to the physical description of the beach--composition, slope, nature of water bottom, amount of water movement. The second included measures of annoyance--presence of litter, natural debris, and flies. The third was an indirect measure of quality--the frequency of maintenance.

Data collection difficulties rendered these three measures inadequate for analytic purposes. The necessarily subjective judgements concerning beach topography were found to be inconsistent. The inventory was made on different days of the week, so the judgements concerning littering (and crowding) were not consistent cross-sectionally. Data on maintenance frequency was difficult to obtain and largely incomplete. Because of these difficulties, the analysis relies on perceived rather than objective quality ratings.

When questioned about the most important characteristic in choosing a site, the absence of litter was ranked first by 31.1% of all respondents. This factor appears to be the single most important factor in determining site preferences. The implications of this finding are twofold. First, maintenance must be provided at any new beaches opened due to water quality improvements. Second, from the narrow standpoint of public recreation policy, money might be more efficiently spent on maintenance of existing beaches rather than improving water quality at any beach.

Crowding:

Crowding is a subjective assessment of the size and temporal and spatial distribution of attendance in relationship to the area of the site. Two approaches were tried to measure objectively this variable. First, during the inventory, crowding at the sites was rated by the project staff. Second, we sought secondary data on attendance, particularly peak day attendance, to estimate crowding. Total average and peak attendance data were consistently unavailable for the sites. By and large, the agencies responsible for these sites neither collected data nor kept records on attendance or crowding. Because no systematic information on crowding was available, we were forced to rely on the respondent's crowding ratings. Because crowding is inherently a perceived characteristic, this may offer better statistical fits, but it begs the question of "explaining" perception.

2.3 Water Quality Variables*

Three main properties of water affect its suitability for recreational use: hygenic factors, aesthetic factors and features which indirectly influence nuisances. (The basic references for this discussion are National Academy of Sciences [17], and Environmental Protection Agency [8].) Table IV-4 summarizes the variables considered in this study and Table IV-5 presents the data for the sites. Note that two parameters, Biological Oxygen Demand (BOD) and Suspended Solids, which are commonly considered in water quality analyses, were omitted from this study. BOD was not determined because of the theoretical and practical invalidity of cross-sectional comparisons between ecosystems. Suspended Solids, commonly thought to be related in a non-linear fashion to fish productivity, were partly accounted in our turbidity measures. Note further, that observations are available for only 29 sites. These are the sites selected prior to the household survey. Constructing a comparable data series for the sites developed in the survey would not have been possible.

This section continues to describe the parameters selected and explains the rationale for their includion. Appendix II details the procedures used to measure the selected parameters.

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*We are indebted to Dr. J.C. Morris, Gordon McKay Professor of Sanitary Chemistry, Harvard University, for assisting in identifying those water quality characteristics pertinent for study. Further assistance in delimiting these parameters was provided by Dr. Fraser Walsh and Dr. Alfred Ajami of Eco Control, Inc., in Cambridge, Massachusetts. Under a subcontract to USR&E, water quality samples were taken under the direction of Eco Control and analyzed by that organization.

Table IV-4

Water Quality Variables

Variable	Acronym	Units	Effect on Water Quality**
Oil or grease	OIL	mg/l	-
Turbidity	JTU	Jackson Turbidity Units	-
Color	COLOR	APHA Platinum Cobalt Standard	-
Odor*	--	Threshold Odor Number	-
pH	PH	pH	-
Alkalinity	ALK	mg/l as calcium carbonate	-
Total Phosphorus	TPOS	mg/l	-
Nitrate	NITR	mg/l	-
Ammonia	AMMO	mg/l	-
Chemical Oxygen Demand	COD	mg/l	-
Temperature	TEMP	Degrees F	?
Fecal Coliform Bacteria	COLI	#/100 ml	-
Total Bacteria	TBAC	#/100 ml	-

*Odor was dropped from the analysis because all sites with the exception of Hopkinton State Park (#29) had no detectable odor.

**"+" means higher values are associated with better water quality, "-" means the opposite.

Table IV-5

Water Quality Data

Site No.	OIL	JTU	COLOR	ODOR	pH	ALK	TPOS	NITR	AMMO	COD	COLI	TBAC	TEMP
01	06.0	4	5	-	8.0	112	.03	-	.6	87	100	250	65.0
02	04.6	2	5	-	8.0	111	.04	-	.3	29	250	7500	64.0
03	09.0	4	4	-	8.1	111	.04	-	.6	57	1500	7500	65.0
04	05.8	1	3	-	8.0	101	.05	-	.6	32	100	2500	66.0
05	08.8	0	5	-	7.9	103	.06	-	.3	41	7500	20000	66.0
06	07.2	2	5	-	7.9	123	.04	-	.2	46	100	750	66.0
07	08.0	3	8	-	7.9	103	.09	.02	.2	34	100	1000	66.0
08	18.0	6	10	-	8.0	112	.06	-	.3	36	100	100	67.0
09	16.8	4	8	-	8.1	106	.06	.01	.4	34	100	1500	66.0
10	33.0	8	21	-	7.9	106	.15	.17	.3	35	500	1500	70.0
11	08.1	10	20	-	7.9	108	.09	.08	.2	81	250	2500	69.0
12	06.8	6	15	-	8.0	110	.10	.01	.3	62	2000	20000	68.0
13	12.2	3	5	-	7.9	106	.06	.01	.3	50	250	2000	68.0
14	9.4	16	16	-	7.9	105	.08	.04	.4	43	9000	25000	67.0
15	7.2	14	15	-	7.9	106	.17	.01	.4	35	17500	40000	65.0
16	19.4	4	8	-	8.1	116	.04	-	.2	-	2000	7500	64.0
17	5.6	0	3	-	8.0	108	.04	-	.2	26	100	100	68.0
18	4.4	0	3	-	8.0	108	.02	-	.2	31	100	100	62.0
19	10.8	0	2	-	8.1	110	.02	-	.1	56	100	100	60.0
20	4.2	6	3	-	8.0	109	.06	-	-	44	100	17500	65.0
21	3.2	5	5	-	7.9	114	.04	-	.2	44	100	1750	65.0
22	4.4	0	5	-	6.1	3	.04	.12	.5	7	4000	35000	69.0
23	3.6	6	16	-	7.7	43	.23	2.20	3.4	25	2000	45000	68.0
24	1.4	4	13	-	6.8	8	.09	.02	.6	13	250	3000	69.0
25	1.8	4	5	-	7.4	26	.09	-	1.0	26	100	12500	71.0
26	1.0	2	5	-	7.2	10	.02	-	.5	8	250	4000	70.0
27	10.2	14	18	-	7.0	10	.06	.02	.8	9	4500	13000	72.0
28	1.4	14	21	-	7.7	26	.05	-	.4	-	500	6000	70.0
29	22.6	23	18	1	6.7	10	.29	.17	.6	8	5000	22500	72.0
Mean	8.8	6	9	-	7.7	84	.08	.10	.5	34	2013	10350	67.0
Std.Dv	3.7	6	6	-	.5	43	.06	.41	.6	22	3790	12764	2.8
Skewness	1.4	1	1	-	-1.9	- 1	2.05	4.99	4.1	0	3	1	- .2
Kurtosis	1.4	1	-1	-	2.7	- 1	3.88	23.28	17.3	0	8	1	- .1

Hygenic Factors

Factors such as pathogen populations, concentrations of toxic substances, clarity, and other similar properties are included. They are most important for direct contact recreation, such as swimming, water-skiing and similar activities, but relate also to secondary contact recreation like fishing, boating and shellfishing. An important characteristic of many factors in this category is that they do not change the perceived desirability of the water and thus do not change utilization unless legal limits are prescribed.

Fecal coliform population counts and total bacteria counts were measured at each site. The possible presence of water-borne pathogenic organisms is deduced usually from the count of fecal coliform organisms, which are indicators of the fecal discharges of man or other mammals. This group of organisms normally does not multiply in the environment and tends to die out within about a month after discharge from the human or animal body.

Currently, proposed EPA maximum limits on fecal coliforms are 2000 per 100 ml average and a maximum of 4000 per 100 ml for waters judged suitable for general recreational use and about one-tenth this for waters designated for bathing or other contact recreation. Table IV-5 reveals that readings higher than these standards were found at several sites.

The presence of fecal coliforms or pathogenic bacteria or viruses does not produce any change in the appearance of the water and so tends not to alter acceptability by users unless legal action occurs or strong publicity is given to the potentially harmful condition of the water.

Standard sewage treatment will reduce fecal coliform counts in sewage by one or two orders of magnitude from about 10^8 per 100 ml. Chlorination of treated sewage will usually reduce the counts to less than recreational water maxima.

Because of lack of suitable monitoring methods and other important information, no viral limits are prescribed even though these agents may survive chlorination levels that will kill fecal coliforms. Shellfish will concentrate viruses from water and so waters to be used for the recreational taking of shellfish are more strictly controlled than other recreational waters.

Aesthetic Factors

These affect primarily the perceived desirability of the water by the recreational user. They are sensory properties, including color, turbidity, oil and grease content, odor and temperature. On occasion properties in this category may also occur in category (1) or (3). For a number of these properties the degradation in quality can be related to the intensity of the property as with color and odor, but this is not true for temperature, for example. Most of these qualities are relevant, in one way or another to both water-based and water-enhanced recreation.

The general appearance of a body of water is a strong factor in its acceptance for recreational uses. Besides properties of color, turbidity and floating plant growths, to be considered individually, the term includes the presence of settleable or of floating solids or oil matter. When these are from waste discharges, they are not only visually objectionable but have other adverse effects as well, such as coating the hulls of boats or the bodies of swimmers.

Settleable matter is obnoxious or deleterious because:

(1) if organic, it forms putrescible deposits that produce hydrogen sulfide and other noxious odorous substances during decomposition;

(2) if inorganic, it forms silt banks and tends to destroy breeding areas for benthal aquatic fauna, essential to fish life, and also egg-hatching areas for many species of fish.

The clarity or transparency of water is directly related to its use for bathing purposes. Drowning and other water hazards increase greatly when bathers cannot be seen underwater. The usual standard is a four-foot "Secchi-disk" transparency, but turbidity is also commonly measured in "Jackson Turbidity Units."

Color affects clarity to some degree, but most impairment of clarity is due to cloudiness or turbidity. Turbidity is characteristic of certain waste discharges, such as those carrying suspended clays or fibres, but may also be produced in the water by excessive growth of algae. This last factor is by far the most common one and is the primary basis for concern about discharges of phosphorus and nitrogen compounds.

High turbidity has also been found to have an adverse effect on fish populations, but at low levels, increased turbidity seems to increase fish yields. Attractiveness of water and its turbidity seem nearly inversely related: so this may be one of the best properties with which to relate water quality and recreational use.

Industrial discharges of phenolic compounds, amines, or other odorous substances may produce directly objectionable odor situations in bodies of water. Secondly, obnoxious odors may arise from the anaerobic decomposition of organic sludge or benthal deposits. Finally, algal or other heavy plant growths may produce odors as part of their natural growth or during their bacterial decomposition after death.

Such odors may provide offensive conditions not only for those in the water or close to it, such as bathers and boaters, but also to picnickers, hikers and others attempting to use the water only as an attractive amenity.

Improvements in water quality on the basis of odor elimination may be expected to occur in three stages: (1) immediately, with the elimination of odorous waste chemicals; (2) with some delay with the reduction in algal growths; and (3) with considerable delay for the odors emanating from sludge deposits unless the body of water itself is treated. Many organic substances similar to those causing odors in water may also lead to tainting of fish flesh with corresponding restrictions on this sort of recreational use.

Increase in temperature affects water quality for recreational use in a number of ways: (1) it stimulates growth of algae and other aquatic plants, thus accentuating the conditions produced by such growth; (2) it may change the relative predominance of algal or plant species to less attractive forms; (3) it has adverse effects on fish populations; and (4) it may cause physiological disturbances in swimmers. The last factor is the basis of the EPA standard that recreational waters should not have temperatures exceeding $85^{0}F$ ($30^{o}C$).

The acid or basic reaction of water, pH, is directly related to recreational use for bathing, for waters with pH far from neutral may lead to eye irritation. In addition, pH values far from neutrality will give situations adverse to aquatic life. Accordingly, water generally suitable for recreational use should have pH 5.0 to 9.0, while acceptable bathing water should have pH 6.5 to 8.3, and deviations from neutrality (7) are a useful linear measure of this effect.

Indirect Nuisance Factors

There are two major subcategories of properties that indirectly bring about nuisance or an undesirable environment: algal nutrients that stimulate undesirable aquatic growths and substances that directly or indirectly have adverse effects on aquatic life, including fish. In this last subcategory are toxicants, oxygen-consuming substances, temperature, silt-forming materials and substances that cause tainting of fish flesh. Some of these were described under Aesthetic Factors above. As with aesthetic properties, the adverse effects here may discourage both water-based and water-enhanced activities.

Excessive growth of algae, particularly in lakes, ponds, pools and estuaries is a principal factor which impairs recreational use of water. Often it is also a principal manifestation of the intrusion of wastewater or polluting substances.

Algae require many elements and growth factors to achieve maximum growth rates and maximum total production. Among them are two forms of substance relatively scarce in most pristine waters, but abundant in domestic sewage and other wastewaters. These are combined nitrogen (ammonium ion, organic nitrogenous material, nitrite or nitrate) and phosphate. When degradation in water quality is the result of increased supply of these substances, treatment for their removal may bring about sharp improvement in water quality. Usually, it is phosphate that is the limiting material in inland waters; in estuaries and the open ocean, combined nitrogen tends to be more critical. The dry mass of algal material is 3 to 8%N and 0.2 to 0.8%P. The total amount of algal material that can be produced at any one time is thus dependent on the amounts of combined nitrogen and phosphate that are available.

No specific acceptability limits have been set for these nutrient substances, but acceptable limits of phosphorus for a situation where it is a limiting constituent for nuisance growth are 0.025 mg per liter of Phosphorus within lakes and reservoirs, 0.05 mg per liter at inlets to lakes and reservoirs, and 0.10 mg per liter in flowing streams.

There is no way to deal adequately in a brief presentation with the large numbers of substances, both inorganic and organic and including radioactive materials, that may find their way on occasion into natural waters and that may be inimical to recreation uses because of toxicity either to man or to some forms of aquatic life. Usually such substances are not directly detected by the user and so tend to inhibit recreational possibilities by proscription rather than by lessened seeming attractiveness. Occasions when any of these types of substances are determining factors in recreation use are rare enough except for catastrophic events--accidental spills or deliberate illegal dumpings--that they generally need not be considered individually in a first-order consideration of relation of water quality to recreational use.

2.4 Factor Analysis of Water Quality Variables

The potential for reducing the number of water quality variables was explored using a cross-sectional factor analysis. (A good reference to the general technique is in Rummel [20].) In addition to reducing the magnitude of the subsequent analytic tasks, this analysis promised a composite index of water quality.

Prior to initiating the analysis, we hypothesized certain relationships among the variables. First, the nutrient variables--

total phosphate (TPOS), organic nitrogen (NITR), and ammonia (AMMO)--would be highly intercorrelated. Similarly the two bacterial variables--coliforms (COLI) and total bacteria (TBAC) would be correlated, and the two measures of acidity/alkalinity--squared deviations of pH from 7(pH) and alkalinity. Turbidity (JTU) and color (COLOR) were hypothesized to correlate as well.

Beyond these obvious relationships further speculation was difficult for reasons outlined in Section IV.2.3, above. Temperature (TEMP) was expected to correlate with bacteria counts, turbidity, and possibly the nutrient measures. Chemical oxygen demand could correlate with oil and grease (OIL), the bacteria measures and the nutrient measures.

The 29x12 data matrix transformed to standardized variables was factored using the SPSS (Statistical Package for the Social Sciences) Version 5.2 classical factor analysis routine. Four factors had eigenvalues greater than one (Table IV-6) and the factoring was stopped. The conventional varimax rotation performed.

Table IV-6

Eigenvalues of Inferred Factors

Factor	Eigenvalue	Percent of Variance
1	4.59685	49.5
2	1.84255	19.9
3	1.80303	19.4
4	1.03523	11.2

At this point let us note a criticism commonly levelled on factor analysis. The eigenvalues are a weighted combination of <u>all</u> water quality variables even though only a few are emphasized in each factor. In terms of standardized variates, the factor analysis accurately trades off the influence of different water quality measures. But management alternatives may not impact the different water quality measures in a standardized way, i.e., proportional to mean level, inversely proportional to the standard deviation. Thus, in a prescriptive analysis, some added computation would be required to use these factors as surrogates for direct water quality measures. However, since we do not simulate the response of recreationists to specified changes in water quality and certain sites, this difficulty does not arise.

The rotated factor matrix is shown in Table IV-7. It depicts both the composition of each variable as a linear function of the factors, and, since the factors are orthoganal, it shows the correlation matrix of factors and variables as well. This matrix tells us the composition of factors.

Factor 1 loads heavily on PH and ALK, as hypothesized. COD also has a substantial correlation, equal to .56, and TEMP has a large positive correlation (.74). This factor distinguishes fresh and salt water sites by its high loading on alkalinity.

Factor 2 accounts for the nutrient variable, loading heavily on NITR, AMMO, and TPOS. It also has a substantial correlation with TBAC. This could be expected because the source of these nutrients is principally domestic wastes, and because they are beneficial to bacterial growth as well. This agrument also suggests that a higher correlation with COLI would be expected.

The third factor represents the clarity measures--JTU and COLOR. OIL also loads heavily, possibly as a surrogate or suspended organic materials. TPOS and TEMP are both positively correlated, which might represent the influence of algal growth on turbidity and color.

Factor 4 is almost exclusively a bacteria factor, with loadings of .90 and .79 on COLI and TBAC, respectively.

Table IV-8 shows the factor score coefficients which represent the transformation between the standardized values of the variables to the factor scores for a particular observation (site). In other words, the cross product of the columns of this table with a row of the standardized data matrix yields the factor score for that site. These factor scores are presented in Table IV-9.

Table IV-7

Varimax Rotated Factor Matrix

	Factor 1	Factor 2	Factor 3	Factor 4
OIL	.19945	-.09860	.59208	-.07898
JTU	-.30753	-.01743	.75006	.36329
COLOR	-.31014	.15834	.76775	.17260
pH	.89853	-.12446	-.14773	-.04908
ALK	.97166	-.17796	.03848	-.08687
TPOS	-.20549	.45742	.64521	.31424
NITR	-.04033	.99361	.07668	.06023
AMMO	-.24947	.91755	-.01047	.08932
COD	.56333	-.04997	-.00028	-.09096
COLI	-.00870	-.04961	.21102	.90023
TBAC	-.17298	.49110	.06150	.79158
TEMP	.74402	.09180	.41616	-.04271

Table IV-8

Factor Score Coefficients

	Factor 1	Factor 2	Factor 3	Factor 4
OIL	-.10537	-.01658	-.05551	.08788
JTU	.02241	.11661	.36451	-.00152
COLOR	-.02258	-.26698	.24888	.06400
pH	.27239	.14010	.32193	-.27116
ALK	.95039	-.10043	.28964	.14454
TPOS	.11528	-.08479	.49527	-.11428
NITR	.11068	1.38445	.26472	-.52784
AMMO	.00819	-.20316	-.24286	.18315
COD	-.16040	.06872	-.12032	.01611
COLI	-.01242	.15560	.13901	.28402
TBAC	.02510	-.21013	-.49892	.89755
TEMP	.01702	.21583	.42160	-.31918

Table IV-9

Factor Scores by Site

Site Number	Factor 1	Factor 2	Factor 3	Factor 4
01	.330650	-.037110	-.602331	-.492970
02	.770742	-.357569	-.632318	-.032098
03	.671290	-.090507	-.476255	-.048942
04	.536167	-.150214	-.424191	-.583751
05	.344646	-.206782	-.846099	1.301178
06	.733737	-.119188	-.233960	-.549294
07	.455647	-.221862	.273409	-.686301
08	.584022	-.180872	.574992	-.715547
09	.636439	-.146644	.291845	-.696832
10	.299133	-.021942	2.052254	-.898088
11	.240946	-.033968	1.401489	-.811897
12	.609568	-.473277	.465519	.553688
13	.310409	.053247	.032738	-.687993
14	.450082	-.210344	.769322	1.717302
15	.707299	-.506396	.793623	3.468664
16	1.023437	-.395671	-.018591	.121545
17	.718979	.134167	.066118	-1.063389
18	.626749	-.275875	-1.001652	-.363595
19	.537515	-.213165	-1.289540	-.229208
20	.703423	-.158402	-.513387	.397690
21	.614024	-.125579	-.247239	-.448357
22	-1.515222	.127071	-1.747724	1.289062
23	-.016647	5.157724	.066998	.263602
24	-1.965580	-.463486	-.400823	-.556174
25	-1.517143	-.309996	-.834642	-.057191
26	-1.985935	-.066204	-1.220096	-.556484
27	-2.057007	-.309797	.265104	.432863
28	-1.197863	-.417920	.933337	-.599095
29	-1.649507	.020561	2.503201	.531601

2.5 Subjective Measures of Site Characteristics

The objective measures presented above were supplemented by perceived site characteristics from the household survey. Respondents were asked:

> For each site you visited would you please rate each of the following characteristics on a scale from 1-5. For this rating, 1 means bad, 2 means moderately bad, 3 is fair, 4 is moderately good, and 5 is good.
>
> A. Water temperature
> B. Water quality (clarity, color, weeds, odor, etc.)
> C. Beach facilities (availability)
> D. Beach quality (setting, maintenance)
> E. Crowding.

Summary statistics of these ratings, by site and in total, are shown in Table IV-10.

Table IV-10

Subjective Variables: Summary Statistics

Variable	Mean	Std.Dev.	Skewness	Kurtosis
Water Temperature Rating	2.656	.660	-.652	.607
Water Quality Rating	2.881	.929	.250	-.611
Beach Facilities Rating	2.703	.710	-.370	.112
Beach Quality Rating	3.207	.832	.592	.835
Crowding Rating	2.838	.799	-.427	.797

3. The Household Survey

As explained above, an extensive review of secondary information sources revealed none was adequate to estimate the demand and benefit models desired. The paucity of data indicated a survey was required to assemble the information necessary for the desired analyses. Several methods are available for obtaining that sort of information. First, structured interviews with recreationists could be held at a sample of sites in the network. This technique has been used in several previous studies of recreation demand;* it has the advantage of being very convenient to organize and relatively cheap. However, for our purposes, it is conceptually unsound. We wish to focus on the recreational preferences of a given population faced with a network of competing sites. We need to know how often a representative member of that population attends each of the different sites; we also need to know the preferences of those persons who do not visit any site. Thus, for our purpose, the relevant sample population is the population to which the network of sites is available, not the population of users of specific sites and alternatives.

Four types of population-oriented surveys are possible: personal, telephone, mail and diary. The telephone survey would have been used if the survey instrument had been brief (less than five minutes for the interview). The problem of telephone ownership bias is not important in a major metropolitan area. Mail surveys offer a low cost method for obtaining responses to a longer questionnaire, but significant problems of self-selection exist. Telephone or personal follow-up could reduce, or at least quantify the selection bias, but such follow-up proved to be not cost-effective. The Bureau of Outdoor Recreation surveys are now done

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*For example, Herbert H. Stoevener [21], S.D. Reiling, K.C. Gibbs, and H.S. Stoevener [19].

by mail, and for most water-related recreation activities they report comparable participation rates between mailed and personal interviews.

Although there have been several recreation mail surveys with response rates well in excess of 50%, these surveys have generally been directed to special interest populations such as licensed fishermen and wilderness users. The general experience with mail surveys directed to the public at large is much less encouraging; with no follow-up the response rate is commonly in the range of 10%-15% and even with one or several follow-ups the response rate is often less than 35%.

Finally, the diary method could provide more accurate responses, more careful selection of respondents but may be difficult to administer. Many consumer surveys are presently performed via the diary method, and this approach should be examined further.

After evaluating the cost, reliability, timing and response bias of the alternative technique, personal in-home interviews were selected as the best medium to collect the needed data. The details of the sample design are presented in the first subsection below. Then the sample population is described in relationship to the universe population. This section closes with a discussion of the survey instrument.

3.1 Sample Design*

The objectives of the sample design were to produce a sample of the Boston SMSA population which approximated the socioeconomic characteristics and geographic dispersion of the SMSA's entire population to meet simultaneously both objectives, a cluster point procedure was adopted.

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*The survey design, sampling, and fieldwork were completed by Cambridge Survey Research, Inc. of Cambridge, Massachusetts, under a subcontract to USR&E. We are particularly indebted to Mr. John Gorman of that organization for his assistance in refining the survey instrument and sample design.

Households were the target respondents, and any available adult member of the household was asked to respond. A probability sample of about 500 interviews was determined which would produce an approximation of the non-institutional population between the ages of 14 and 65 of the Boston area SMSA. This would constitute an overall sampling fraction of 500/661650 or about 7.6 households per thousand. This is about the same sampling frequency as that of the Harvard-MIT Joint Center for Urban Studies in a 1970 survey of outdoor recreation and leisure activity in the Boston SMSA which was conducted for the Massachusetts Department of Natural Resources.

Towns were picked as primary sampling units. Each town falling in the SMSA was proportioned for a specific number of interviews according to its population between the ages of 14 and 65. Some of these towns were proportionately too small to warrant a sufficient number of interviews to be sampled. A certain number of towns which were most representative on demographic variables of all the towns were chosen to be sampled. Twenty-three towns from the total 77 towns comprising the SMSA were sampled. Table IV-11 shows the distribution of sample points and respondents between towns, and Figure IV-2 shows a map of the sample points and sites.

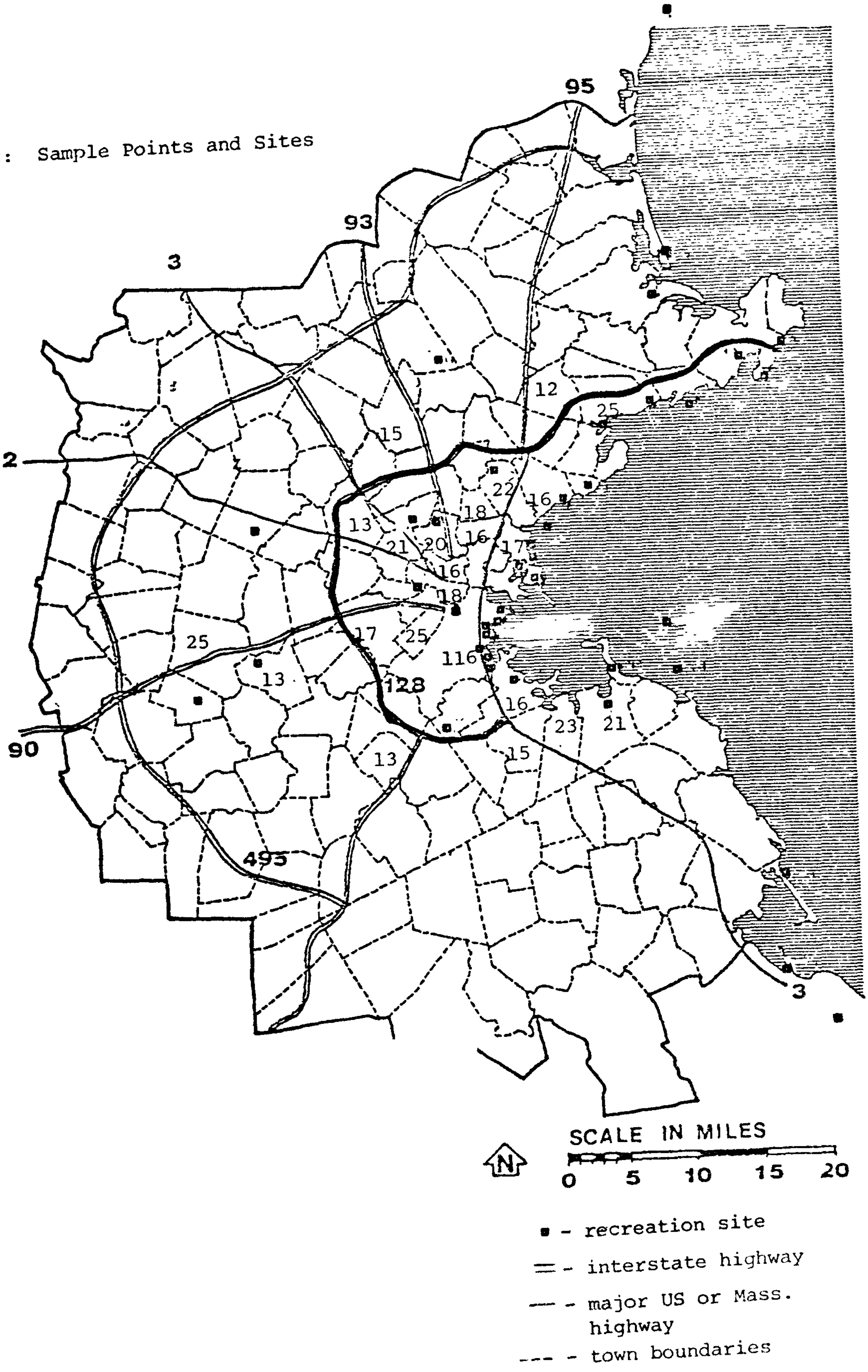
Each town was then systematically sampled. Towns were sub-divided down to the Census block level. A sampling fraction was computed for each town, and blocks were chosen at specific intervals by the sampling fraction with a random start. Thus, within each town, we had specific census tracts picked and specific blocks within that census tract to be interviewed. Each block area was assigned a cluster of five interviews.

Table IV-11

Distribution of Sample Points Between Towns

Town	
Lynn	16
Saugus	11
Danvers	12
Beverly	23
Cambridge	18
Newton	17
Somerville	16
Wilmington	15
Framingham	25
Arlington	21
Natick	13
Norwood	13
Lexington	13
Malden	16
Medford	20
Melrose	18
Hingham	21
Boston	116
Revere	17
Quincy	16
Brookline	25
Weymouth	23
Braintree	15

Figure IV-2: Sample Points and Sites



This survey was administered in the respondents' homes during December 1974 by supervised professional interviewers, specially trained for this survey. We had planned to conduct the survey during the first week in September (immediately after Labor Day which is commonly considered the end of the summer recreation period), but a three-month delay in obtaining OMB clearance which was completely beyond our control forced postponing the survey until the first week in December. The effect of this delay on the survey results is unknown, but previous studies have found that respondents' recollections of the recreation experience becomes more favorable as time passes. Subjective quality ratings may, therefore, overstate true perceptions, possibly accounting for the poor correlation between objective and perceived quality found in the next chapter. No doubt, the accuracy of numeric information, such as number of visits, expenditures, etc., suffered from the deterioration of recall during the long hiatus.

Interviewers began at a randomly chosen starting point. A skip pattern of housing units was also determined in order to distribute the five clustered interviews evenly over the sample point. Interviewers were instructed to keep a one-to-one male/female ratio. The person most qualified to speak regarding family activities was designated as the proper respondent.

Where no one at the household selected was available for interview, random replacement was used to find a substitute. To find a substitute, the following pattern was employed until a respondent was found. First, the housing unit on the right is tried, then the one to the left, then the one across to the left, then across to the right and finally, the housing unit directly across is tried. Within the various cluster points substitutes are not of concern because within the cluster, respondents and non-respondents are statistically indistinguishable.

Finished interviews were returned as they were completed, and were checked and edited for accuracy. About 10 percent of each interviewer's work was selected randomly and was validated for authenticity.

3.2 The Sample Population

Selected socioeconomic characteristics of the sample of respondents and the Boston SMSA population are presented in Table IV-12. Median income of the two groups is nearly identical; average income is within the error of projections in the poisson distribution. The sample contains slightly more men than the population as a whole, and in general, is better educated. The racial composition of the sample is somewhat anomolous , because 20.8% of the respondents listed their race as "other unspecified." This may have been a reaction to the question which was designed to discriminate between Irish and Italian Caucasion as well as between Blacks from all Caucasians:

How would you describe your ethnic background?

a. American Indian
b. Asian-American
c. Black
d. Irish
e. Italian
f. Spanish Surname
g. Other Caucasian
h. Other (please specify) ___________

The "Other" category is likely to include people of diverse backgrounds (Russian, German, Jewish, Armenian, etc.) who would normally describe themselves as "White."

Table IV-12

Comparison of the Boston SMSA Population and the Sample

	Sample	Boston SMSA (1970)
Number of Households	467	661,650
Family Income ($)		
Median	11,445	11,449
Mean	13,214	13,284
Sex (%) of Respondent		
Male	46.9	45.5
Female	53.1	54.5
Education of Respondent		
not completed high school	20.3	35.6
completed high school	32.5	36.8
some college	22.6	4.9
completed college	14.7	8.1
post-graduate	9.9	7.6
Race (%)		
White	68.9	94.5
Black	4.8	4.6
Other	26.6	.9

3.3 The Survey Instrument

The survey instrument contained in Appendix III is designed to elicit information on the sensitivity of demand for water-based recreation to changes in water quality. Three types of behavior in response to altered water quality are explicitly examined: substitutions between sites, substitutions between activities (including non-water-based outdoor recreation), and loss of benefit when no substitution occurs. This section describes the general development of this instrument and then concludes by discussion in detail the intent of each question or group of questions.

The survey instrument was developed after a careful analysis of the data required and review of previous similar recreation surveys.*

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*The survey instruments reviewed include those found in:

Boston Area Study: 1970 [11].

Water Quality Criteria for Selected Recreational Uses: Site Comparison [2].

The Recreational Uses of Green Bay: A Study in Human Behavior and Attitude Patterns [6].

Benefits of Water Pollution Control on Property Values [7].

Stream Quality Preservation Through Planned Urban Development [4].

A Case Study of Yaquina Bay, Oregon [21].

Economic Benefits from an Improvement in Water Quality [19].

Benefits of Water Quality Enhancement [18].

Transactions of American Fisheries Society [1].

The Demand for Motorboat Use in Large Reservoirs in Arizona [12].

An Economic Evaluation of the Oregon Salmon and Steelhead Sport Fisheries [3].

Metropolitan Washington Council of Governments Water Quality Survey [22].

Where specific questions have been adapted, the appropriate references are presented in the more detailed discussion which follows below. Based on these needs and the literature review, an initial survey instrument was drafted. This draft was reviewed internally by the project staff. Once suitable form and content had been reconciled internally, experts in recreation planning and survey research, not directly involved in the project, were asked to review the instrument.* Based on this review, the instrument was pretested and then finalized. The entire interview required about one-half hour to administer.

The survey instrument is divided into three sections. Part 1 generates the multi-site visitation data required to estimate the demand model described elsewhere. Part II attempts to measure directly the behavioral response to altered water quality. In Part III, socioeconomic information on the respondent and his household is developed to provide a backdrop for the required analyses.

Part I, "Participation in Water-Based Recreation" generates the information required to estimate statistically the benefits from water pollution abatement. Question 2 elicits information on the visitation by both the respondent himself and his household to a system of sites in the Boston Study Area. Questions 3-6 obtain the details of each visit including mode, cost and time of travel, on-site expenditures and activities while on-site. Distance to the site was, as explained above, calculated from a grid imposed on the study area map. This data, along with the data on fixed costs of recreation and socioeconomic identified in Part III comprises the basis for statistically estimating the benefits of water quality enhancement.

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*We thank William Geizentanner, Janet Marantz, John Gorman and Sherwin Feinhandler for their assistance in this review.

Question 7 of Part I leads to the measurement of perceived water quality and its relationship to recreation usage. This question assesses the reasons for not visiting the closest site. Utility is maximized with respect to distance at this point, so the tradeoffs between other characteristics (beach facilities, water quality, crowding, cost, etc.) can be more distinctly drawn.

Part II requests perceptions concerning site characteristics, and response to changes in those characteristics. First a rating is established in Question 1. This rating is used in conjunction with objective measures of water quality to ascertain the parameters which most directly affect perceived water and beach quality. Question 2 defines the decision set of sites, and obtains a ranking for those sites as well. Question 4 uses this ranking to determine directly response to altered water quality, beach characteristics, and so on.

The most frequently visited site is the focus of our probing. Presumably the respondent is most familiar with this site, and in some sense its mix of attributes optimizes his utility. First, the predominant reason for visiting that site is determined. Then the responses to declines (based on the ranking established in the previous question) in the quality of site characteristics and site closing are elicited. This series of questions attempts to determine directly the site and activity substitutions which our demand model infers. These questions provide both a check on the model and also determine more detailed information on interactivity substitutions.

More general questions on quality perceptions are asked in Questions 5 and 6.* First, the importance of water quality with respect to other site characteristics is established (Question 5). Then, focusing on water quality, the relative importance of five general parameters of water quality is established.

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*These Questions are derived in part from Auckerman [2] and Dornbusch [7].

Part II closes with an assessment of the importance and substitutability of various activities. Question 7 relates to water-based activities, and provides the basis for turning the perceptions of water quality into recreation water quality priorities. Question 8 treats non-water-based activities to establish the basis for activitiy substitution assessed in Question 4. Then Question 9 directly assesses the potential for substitution of water-based and non-water-based activities. Part II concludes with a more general open-ended question on the recreation provided in the system of sites.

Part III, Identification, provides the respondent's socioeconomic background for use in the demand modeling effort and for analyzing the perceptions obtained in Part II. The age ranges in Question 2 were chosen to reflect categories which could affect recreational habits. Previous studies have found income, occupation and education to influence recreational behavior, and these data are solicited in Questions 4-8. The fixed costs of recreation are determined in Question 9.* Recreation economists have posited that the common omission of these fixed costs in benefit research has artifically depressed estimates of the social value of recreation.

Finally, Questions 10-13 relate to other exogenous determinants of recreation participation. Question 10 asks for weekly and annual leisure time. Questions 11 and 12 determine the potential from travel to the recreation sites by automobile and public transit, respectively. Lastly, previous research on recreation in the Boston area suggests that ethnicity is an important determinant of site choice. Question 13 elicits the information to test this hypothesis, and control for its effect in our statistical analysis.

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*This question is adapted from Reiling, Gibbs, and Stoevener [19].

4. Measures of Attendance

Our demand models use as a dependent response variable measure of attendance at each site. Chapter II outlined some of the characteristics of an adequate measure of demand, and pointed out that our focus on one-day trips eliminated some of the vaguaries of measuring activity duration. Initially, five measures of visitation were considered:

(1) MNT: the number of times a site was mentioned and for an individual, the binary variable on whether or not a site was mentioned (number);

(2) PVS: the number of visits made to a site by the respondent (person-visits);

(3) HVS: the number of visits to a site by anyone in the respondent's household (person-visits);

(4) GVS: the number of household visits multiplied by the average group size (person-visits); and

(5) VSDR: the number of household visits multiplied by the average duration (person-hours).

All of these variables were derived in the obvious manner from four questions:

The card shows some of the major fresh and salt water beaches in the Boston Area. Could you please tell me: (hand respondent site list)

A. Which sites did you personally visit, and how many times did you visit each of those sites. Are there any sites, town beaches, ponds or other fresh or walt water areas, which you visited that are not on this list? (Record those sites and the number of visits to each. Add visits and ask:)

So you personally visited a beach, lake or stream about ____ times this past summer?

B. Now I would like to find out about visits by anyone in this household to fresh and salt water beaches in the Boston Area. Could you please tell me the number of visits by any household member to each of these sites. Are there any sites, town beaches, ponds or other fresh or salt water areas, which you visited that are not on the list? (Record those sites and the number of visits to each. Add visits and ask:)

So members of this household visited a beach, lake or stream about ____ times this past summer.

C. About how long, on average, was spent at each of the sites you listed in the two questions above?

D. For each site about how many people from your household, on average, made the trip?

The correlations between these variables is shown in Table IV-13. The measures have similar distributions across sites, and display a high degree of intercorrelation.

Table IV-13

Correlation Between Attendance Measures Across Sites*

	PVS	HVS	GVS	VSDR
MNT	.8100	.8350	.7823	.8692
PVS		.9605	.8413	.8836
HVS			.8916	.9608
GVS				.8454

*All coefficients are based on 43 observations, and all are significant at the 5% level.

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V. DIRECT EMPIRICAL FINDINGS ON SITE CHOICE AND WATER QUALITY PERCEPTION

In this chapter two types of analysis are used to detect the response of recreationists to water quality. First respondents were asked to rank water quality along with other determinants of site choice. In general, this approach finds that proximity and beach characteristics (facilities, cleanliness and setting) are much more important than water quality in determining site choice. If water quality improvements open sites close to major population centers, then benefits may be generated.

Second, the relationship between objective measures of water quality and the subjective water quality rating is probed in Section V.2. Logic suggests that strong correlation between objective and subjective measures is a necessary but not sufficient condition for demand to show any response to changes in water quality. Despite a rigorous analysis of the data, we find weak, if any, association between the objective and subjective measures. While the engineer or public health scientist may measure improvements or declines in water quality, the public will not, it seems, perceive those changes.

1. Direct Questioning

Respondents were questioned directly concerning importance of various factors, including water quality to their recreational behavior. Four questions were posed:

1.1 The Favorite Site

Let's talk about the beach, lake, or river site you visited most. That was ______ , site number ______. (Hand Respondent Card D)

A. Why do you visit this site most often? (Code most important reasons)

a. it is close
b. it is cheap
c. the water temperature is nice
d. the water quality is good
e. my family always came here
f. not too crowded
g. nice setting
h. beach is clean
i. nice facilities
j. my friends go there
k. other ____________

This of all the questions is probably the best indicator of behavior because the respondent considers and explains specific rather than generic behavior. Responses to this question are shown in Table V-1. Proximity is clearly the most important factor (47.5%). That friends go there, what we describe as a cultural factor, is the second most important reason (12.3%). Factors related to the beach quality (lack of litter--10.3%, and setting--11.7%) are the third and fourth most frequently mentioned responses, but are much less important than proximity. Water quality only gains 3.9% of the responses.

Response was tested against income, family size, education, occupation, race, amount of recreational equipment, and the amount of leisure time, automobile ownership, use of public transit and vacation time. Only income and family size affected the response distribution at a 5% level of significance. For all family sizes, proximity is the most important reason cited. The presence of friends is more important to larger families than

Table V-1

Reason for Choosing Favorite Site

Response		Number	Percentage
a.	it is close	170	47.5
b.	it is cheap	2	.6
c.	the water temperature is nice	11	3.1
d.	the water quality is good	14	3.9
e.	my family always came here	17	4.7
f.	not too crowded	13	3.6
g.	nice setting	42	11.7
h.	beach is clean	37	10.3
i.	nice facilities	8	2.2
j.	my friends go there	44	12.3

smaller ones. Similarly, larger families respond to water quality more readily than do smaller ones. These results are shown in Table V-2.

Table V-3 shows the income cross tabulation. Again proximity is always the most important reason, but declines in importance with higher incomes. Conversely, the importance of beach cleanliness increases moderately with higher incomes. The cell counts for water quality are too small to discern with any confidence the income trend, however.

Table V-2

Cross Tabulation of Reason for Visiting

Favorite Site and Family Size

REASON:	Family Size (# of members) 1	2	3	4	5	6	7	8	9	10
a. it is close	(5) 3.0 35.7	(27) 16.0 42.4	(22) 13.0 43.1	(52) 30.8 58.4	(26) 15.4 43.4	(16) 9.5 43.2	(8) 4.7 50.0	(8) 4.7 57.1	(2) 1.2 50.0	(3) 1.8 37.8
b. it is cheap	(0) 0 0	(1) 50.0 1.6	(0) 0 0	(0) 0 0	(0) 0 0	(1) 50.0 2.7	(0) 0 0	(0) 0 0	(0) 0 0	(0) 0 0
c. the water temperature is nice	(0) 0 0	(1) 9.1 1.6	(0) 0 0	(4) 36.4 4.5	(1) 9.1 1.7	(2) 18.2 5.4	(1) 9.1 6.3	(0) 0 0	(1) 9.1 25.0	(1) 9.1 12.5
d. the water quality is good	(0) 0 0	(3) 21.4 4.7	(1) 7.1 2.0	(3) 21.4 3.4	(5) 35.7 8.3	(0) 0 0	(2) 14.3 12.5	(0) 0 0	(0) 0 0	(0) 0 0
e. my family always came here	(2) 11.8 14.3	(0) 0 0	(2) 11.8 3.9	(3) 17.6 3.4	(5) 29.4 8.3	(1) 5.9 2.7	(2) 11.8 12.5	(0) 0 0	(1) 5.9 25.0	(1) 5.9 12.5
f. not too crowded	(1) 7.7 7.1	(2) 15.4 3.1	(0) 0 0	(1) 7.7 1.1	(2) 15.4 3.3	(5) 38.5 13.5	(0) 0 0	(0) 0 0	(0) 0 0	(2) 15.4 25.0
g. nice setting	(2) 4.8 14.3	(8) 19.0 12.5	(9) 21.4 17.6	(12) 28.6 13.5	(2) 4.8 3.3	(5) 11.9 13.5	(2) 4.8 12.5	(2) 4.8 14.3	(0) 0 0	(0) 0 0
h. beach is clean	(2) 5.4 14.3	(13) 35.1 20.0	(8) 21.6 15.7	(6) 16.2 6.7	(6) 16.2 10.0	(2) 5.4 5.4	(0) 0 0	(0) 0 0	(0) 0 0	(0) 0 0
i. nice facilities	(0) 0 0	(0) 0 0	(2) 25.0 3.9	(2) 25.0 2.2	(4) 50.0 6.7	(0) 0 0	(0) 0 0	(0) 0 0	(0) 0 0	(0) 0 0
j. my friends go there	(2) 4.5 14.3	(9) 20.5 14.1	(7) 15.9 13.7	(6) 13.6 6.7	(9) 20.5 15.0	(5) 11.4 13.5	(1) 2.3 6.3	(4) 9.1 28.6	(0) 0 0	(1) 2.3 12.5

*Significant at 5% level, cells show number in ( ), row percentage and column percentages.

Table V-3

Cross Tabulation of Reasons*

For Choosing Favorite Site and Income

REASON:	Income Class 1	2	3	4	5	6	7	8	9	10	11
a. it is close	(8) 8.9 42.9	(15) 11.1 53.6	(20) 14.8 52.8	(19) 14.1 52.8	(16) 11.9 41.0	(31) 23.0 56.4	(12) 8.9 44.4	(4) 3.0 28.6	(3) 2.2 42.9	(0) 0 0	(3) 2.2 37.5
b. it is cheap	(0) 0 0	(0) 0 0	(0) 0 0	(0) 0 0	(0) 0 0	(0) 0 0	(1) 50.0 3.7	(1) 50.0 7.1	(0) 0 0	(0) 0 0	(0) 0 0
c. the water temperature is nice	(1) 11.1 3.6	(0) 0 0	(2) 22.2 4.3	(2) 22.2 5.6	(0) 0 0	(2) 22.2 3.6	(0) 0 0	(1) 11.1 7.1	(0) 0 0	(0) 0 0	(1) 11.1 12.5
d. the water quality is good	(2) 18.2 7.1	(1) 9.1 3.6	(2) 18.2 4.3	(0) 0 0	(2) 18.2 5.1	(4) 36.4 7.3	(0) 0 0	(0) 0 0	(0) 0 0	(0) 0 0	(0) 0 0
e. my family always	(1) 7.1 .7	(0) 00 00	(4) 28.6 8.7	(1) 7.1 2.8	(3) 21.4 7.7	(1) 7.1 1.8	(2) 14.3 7.4	(1) 7.1 7.1	(0) 0 0	(0) 0 0	(1) 8.3 12.5
f. not too crowded	(0) 0 0	(2) 16.7 7.1	(1) 8.3 2.2	(0) 0 0	(3) 25.0 7.7	(1) 8.3 1.8	(1) 8.3 3.7	(2) 16.7 14.3	(0) 0 0	(1) 8.3 100.0	(1) 8.3 12.5
g. nice setting	(4) 11.1 14.3	(0) 0 0	(8) 22.2 17.4	(4) 11.1 11.1	(4) 11.1 10.3	(7) 19.4 12.7	(2) 5.6 7.4	(2) 5.6 14.3	(3) 8.3 42.9	(0) 0 0	(2) 5.6 25.0
h. beach is clean	(2) 6.1 7.1	(2) 6.1 7.1	(5) 15.2 10.9	(8) 24.2 22.2	(5) 15.2 12.8	(5) 15.2 9.1	(4) 12.1 14.8	(1) 3.0 7.1	(1) 3.0 14.3	(0) 0 0	(0) 0 0
i. nice facilities	(3) 42.9 10.7	(0) 0 0	(1) 14.3 2.2	(0) 0 0	(1) 14.3 2.6	(1) 14.3 1.8	(1) 14.3 3.7	(0) 0 0	(0) 0 0	(0) 0 0	(0) 0 0
j. my friends go there	(3) 10.0 10.7	(8) 26.7 28.7	(3) 10.0 6.5	(2) 6.7 5.6	(5) 16.7 12.8	(3) 10.0 5.5	(4) 13.3 14.8	(2) 6.7 14.3	(0) 0 0	(0) 0 0	(0) 0 0

*Significant at 5% level, cells show number in ( ), row percentages and column percentages.

1.2 Characteristics Important for Site Choice

In choosing a site what are the three most important characteristics?

a. presence of a bathhouse/changing room
b. absence of litter
c. presence of a lifeguard
d. presence of a marine/boat launching facility
e. stocked game fish/good fishing
f. a natural setting
g. water temperature
h. water appearance
i. presence of other beach facilities
j. cost (parking fees, entry fees)
k. proximity
l. where your friends go
m. where your family always went
n. other __________

We anticipated this question would yield less reliable results than the first one since it is more vague and general. Table V-6 shows the response to this question. Here absence of litter is the most important reason followed by the presence of beach facilities (bathhouse, lifeguard) and a nice setting, water appearance, rates, fifth, and proximity, sixth.

Several features of this response pattern are notable. The most obvious is the relative lack of importance ascribed to proximity. Two explanations suggest themselves. First, when considering the generic question of motivation, respondents discount proximity, although it is quite important to determine actual behavior. An alternative hypothesis is that many more respondents understood the meaning of "it is close" than knew the definition of "proximity."

The responses were tested against income, family size, race, occupation, education, amount of recreational equipment, automobile ownership, amount of leisure time each week, vacation time and use of public transit.

Table V-4

Important Characteristics for Site Choice

Characteristic	Most Important #	Most Important %	2nd Most Important #	2nd Most Important %	3rd Most Important #	3rd Most Important %
a. presence of a bathhouse/ changing rooms	62	13.7	28	6.3	33	7.6
b. absence of litter	141	31.1	109	24.5	48	11.0
c. presence of a lifeguard	49	10.8	48	10.8	37	8.5
d. presence of a marina/ boat launching facility	5	1.1	12	2.7	6	1.4
e. stocked game fish/ good fishing	5	1.1	5	1.1	10	2.3
f. a natural setting	52	11.5	37	8.3	42	9.6
g. water temperature	14	3.1	38	8.6	26	5.9
h. water appearance	43	9.5	71	16.0	74	16.9
i. presence of other beach facilities	4	.9	16	3.6	16	3.7
j. cost (parking fees, entry fees)	3	.7	31	7.0	43	9.8
k. proximity	37	8.2	17	3.8	44	10.1
l. where your friends go	18	4.0	16	3.6	25	5.7
m. where your family always went	7	1.5	5	1.1	14	3.2
n. other	13	2.9	11	2.5	19	4.3

The null hypothesis of independent classification can be rejected at the 5% level for education and occupation. The contingency tables are presented in Tables V-5 and V-6, respectively. Higher levels of education lead to a greater sensitivity to a natural setting. At the same time, proximity becomes more important with increased education. Because setting and proximity are inversely related, this table suggests that respondents not understanding the definition of "proximity" may explain, at least in part, the markedly differing results from these two questions.

These results have two interesting implications, one methodological and one substantive. The first is that the wording of the questionnaire is of great importance to subsequent findings. Although our survey instrument was carefully developed, reviewed and pretested, this anomaly persisted and seems to have made a difference.

Secondly, facilities appear to be important to recreation demand. Any recreation benefits from water quality improvements may not be obtained unless further investments in beaches, changing facilities, maintenance and lifeguards are made. Additional money, perhaps raised through user fees, would be required to provide these facilities.

Table V-5

Most Important Site Characteristics
Tabulated by Education

CHARACTERISTIC	Education 1	2	3	4	5	6	7
a. presence of a bath-house/changing rooms	(0) 0 0	(1) 1.6 7.7	(21) 34.4 17.9	(13) 21.3 15.9	(5) 8.2 17.9	(17) 27.9 14.2	(4) 6.6 4.8
b. absence of litter	(1) .7 16.7	(5) 3.6 38.5	(31) 22.3 26.5	(33) 23.7 40.2	(8) 5.8 28.6	(36) 25.9 30.0	(25) 18.0 30.1
c. presence of life-guard	(2) 4.1 33.3	(2) 4.1 15.4	(15) 30.6 12.8	(9) 18.4 11.0	(3) 6.1 10.7	(9) 18.4 7.5	(9) 18.4 10.8
d. presence of a marina/boat launching facility	(0) 0 0	(0) 0 0	(1) 20.0 .9	(1) 20.0 1.2	(0) 0 0	(3) 60.0 2.5	(0) 0 0
e. stocked game fish/good fishing	(0) 0 0	(0) 0 0	(3) 60.0 2.6	(0) 0 0	(0) 0 0	(1) 20.0 .8	(1) 20.0 1.2
f. a natural setting	(1) 1.9 16.7	(1) 1.9 7.7	(7) 13.5 6.0	(11) 21.2 13.4	(2) 3.8 7.1	(16) 30.8 13.3	(14) 26.9 16.9
g. water temperature	(0) 0 0	(0) 0 0	(7) 50.0 6.0	(0) 0 0	(2) 14.3 7.1	(4) 28.6 3.3	(1) 7.1 1.2
h. water appearance	(1) 2.3 16.7	(0) 0 0	(11) 25.6 9.4	(8) 18.6 9.8	(2) 4.7 7.1	(11) 25.6 9.2	(10) 23.3 12.0
i. presence of other beach facilities	(1) 25.0 16.7	(0) 0 0	(1) 25.0 .9	(0) 0 0	(1) 25.0 3.6	(1) 25.0 .8	(0) 0 0
j. cost (parking fees, entry fees)	(0) 0 0	(0) 0 0	(1) 33.3 .9	(1) 33.3 1.2	(0) 0 0	(0) 0 0	(1) 33.3 1.2
k. proximity	(0) 0 0	(2) 5.4 15.4	(7) 18.9 6.0	(2) 5.4 2.4	(3) 8.1 10.7	(11) 29.7 9.2	(12) 32.4 14.5
l. where your friends go	(0) 0 0	(1) 5.6 7.7	(8) 44.4 6.8	(3) 16.7 3.7	(0) 0 0	(6) 33.3 5.0	(0) 0 0
m. where your family always went	(0) 0 0	(1) 16.7 7.7	(1) 16.7 .9	(0) 0 0	(2) 33.3 7.1	(1) 16.7 .8	(1) 16.7 1.2
n. other	(0) 0 0	(0) 0 0	(3) 23.1 2.6	(1) 7.7 1.2	(0) 0 0	(4) 30.8 3.3	(5) 38.5 6.0

Table shows cell count in ( ), row percentages and column percentages.

Table V-6

Most Important Site Characteristics Tabulated by Occupation

Characteristic	Occupation 1	2	3	4	5	6	7	8	9	10
a. presence of a bathhouse/changing rooms	(15) 25.4 12.3	(7) 11.9 9.5	(2) 3.4 16.7	(13) 22.0 15.7	(4) 6.8 7.8	(1) 1.7 4.3	(9) 15.3 34.6	(1) 1.7 11.1	(1) 1.7 16.7	(6) 10.2 16.7
b. absence of litter	(37) 27.2 30.3	(21) 15.4 28.4	(5) 3.7 41.7	(27) 19.9 32.5	(15) 11.0 29.4	(10) 7.4 43.5	(6) 4.4 23.1	(4) 2.9 44.4	(2) 1.5 33.3	(9) 6.6 25.0
c. presence of lifeguard	(15) 31.3 12.3	(8) 16.7 10.8	(1) 2.1 8.3	(10) 20.8 12.0	(5) 10.4 9.8	(2) 4.2 8.7	(2) 4.2 7.7	(0) 0 0	(2) 4.2 33.3	(3) 6.3 8.3
d. presence of a marina/boat launching facility	(0) 0 0	(2) 40.0 2.7	(0) 0 0	(0) 0 0	(0) 0 0	(0) 0 0	(0) 0 0	(0) 0 0	(0) 0 0	(3) 60.0 8.3
e. stocked game fish/good fishing	(1) 20.0 .8	(1) 20.0 1.4	(0) 0 0	(2) 40.0 2.4	(0) 0 0	(1) 20.0 4.3	(0) 0 0	(0) 0 0	(0) 0 0	(0) 0 0
f. a natural setting	(18) 34.6 14.8	(7) 13.5 9.5	(0) 0 0	(9) 17.3 10.8	(9) 17.3 10.8	(3) 5.8 13.0	(3) 5.8 11.5	(1) 1.9 11.1	(1) 1.9 16.7	(1) 1.9 2.8
g. water temperature	(3) 23.1 2.5	(2) 15.4 2.7	(0) 0 0	(4) 30.8 4.8	(4) 30.8 4.8	(0) 0 0	(1) 7.7 3.8	(0) 0 0	(0) 0 0	(0) 0 0
h. water appearance	(10) 23.3 8.2	(13) 30.2 17.6	(0) 0 0	(4) 9.3 4.8	(6) 14.0 11.8	(2) 4.7 8.7	(1) 2.3 3.8	(3) 7.0 33.3	(0) 0 0	(4) 9.3 11.1
i. presence of other beach facilities	(2) 50.0 1.6	(0) 0 0	(2) 50.0 16.7	(0) 0 0	(0) 0 0	(0) 0 0	(0) 0 0	(0) 0 0	(0) 0 0	(0) 0 0
j. cost (parking fees, entry fees)	(1) 33.3 .8	(0) 0 0	(0) 0 0	(0) 0 0	(1) 33.3 2.0	(0) 0 0	(0) 0 0	(0) 0 0	(0) 0 0	(1) 33.3 2.8
k. proximity	(13) 35.1 10.7	(7) 18.9 9.5	(0) 0 0	(6) 16.2 7.2	(4) 10.8 7.8	(3) 8.1 13.0	(0) 0 0	(0) 0 0	(0) 0 0	(4) 10.8 11.1
l. where your friends go	(2) 11.1 1.6	(3) 16.7 4.1	(1) 5.6 8.3	(5) 27.8 6.0	(2) 11.1 3.9	(0) 0 0	(2) 11.1 7.7	(0) 0 0	(0) 0 0	(3) 16.7 8.3
m. where your family always went	(1) 16.7 .8	(0) 0 0	(0) 0 0	(2) 33.3 2.4	(2) 33.3 3.9	(0) 0 0	(1) 16.7 3.8	(0) 0 0	(0) 0 0	(0) 0 0
n. other	(4) 30.8 3.3	(3) 23.1 4.1	(1) 7.7 8.3	(1) 7.7 1.2	(0) 0 0	(1) 7.7 4.3	(1) 7.7 3.8	(0) 0 0	(0) 0 0	(2) 15.4 5.6

Table shows cell count in ( ), row percentages and column percentages.

1.3 Not Visiting Closest Site

The third question asks the converse of the first one:

(If the respondent did not visit the closest site, ask:) (Hand respondent Card B)

______________ beach is the major recreation site closest to your home, yet you did not mention having visited it. Here are some reasons, which one best explains why you did not visit that site?

a. not aware of that site
b. do not like the facilities
c. too crowded
d. beach too dirty
e. water too cold
f. water too dirty
g. don't own auto, not accessible by public transportation
h. too expensive
i. not interested in the activities available there
j. other (please specify) ________________

Here we control for proximity to assess the rationale behind site choice. The principal shortcoming of this question is that, since the respondent does not visit the closest site, his knowledge of it may be dated or secondhand.

Table V-7 shows the response distribution to this question. It is remarkable, given the apparent importance of proximity to attendance, that 60.2% of the respondents did not visit the closest sites. Of course, the second most close site was, in many sample clusters, quite close by. The importance of this finding is mitigated somewhat by the widespread ignorance of the closest site (response a). The ignorance hypothesis is further confirmed by the second most important reason, "not interested in the activities available there," because the beaches were offered quite homogenous activities: swimming, boating, fishing, picnicking, bicycling, strolling and informal sports were available at all, and only a few offer facilities for tennis, basketball and other similar specialized sports.

Table V-7

Distribution of Reasons for not Visiting Closest Site

Reason	No.	Percent
a. not aware of that site	69	24.6
b. do not like the facilities	14	5.0
c. too crowded	31	11.0
d. beach too dirty	24	8.5
e. water too cold	0	0
f. water too dirty	32	11.4
g. don't own auto, not accessible by public transportation	2	.7
h. too expensive	0	0
i. not interested in the activities available there	39	13.9
j. other	70	24.9
TOTAL	281	

Dirty water and crowding ranked third and fourth, respectively as major deterents to attendance. The hypothesis that good water quality does not encourage attendance, but bad water quality discourages it suggests itself, but is not confirmed by the willingness-to-pay analysis presented below. Judging from the low correlations between water quality and water quality perceptions, "the water is too dirty," may be another way of saying "I don't visit the site because I am told it is not very nice." Hence a public agency might reduce attendance at a polluted site by identifying it as such. And, the converse may also be true: water quality improvements may not increase use unless there is adequate publicity that the beach is open for swimming or that the water quality has been improved. This may be particularly important for sites where water quality has been poor for some time, such as the lower Charles River in Boston.

The obvious hypotheses concerning the effects of income, race, education, occupation, automobile ownership, public transit usage, vacation time, and leisure time on reasons for selecting a site were tested via contingency tables and no effect was found to be statistically significant at the 5% level. Once those who do visit the closest site have been removed from the sample, it is easy to see why those remaining do not differ along these socioeconomic lines, but the income of those visiting the closest site is not statistically different from the income of those who visit more distant sites.

1.4 Importance of Various Water Characteristics

The final direct question used to probe the relationship between recreation behavior and water quality focused on the characteristics people feel are important to good water quality:

> Thinking of water quality, attractiveness of the water for swimming depends on the color, odor, clearness, amount of floating debris or scum, and the amount of aquatic weeds. Which characteristic

is the most important? 2nd most important? Please rank these characteristics.

a. color
b. odor
c. clearness
d. floating debris
e. aquatic weeds.

Responses to this question are tabulated in Table V-8. Clarity (the converse of turbidity) and the absence of floating debris appear to be the most important parameters of water quality. These results contrast with the observed ratings which show only color to be correlated with water quality perception (Section IV-4 above). In this ranking color is next to last in importance. Several explanations for this contrast are possible. The best is that this question, generic rather than specific, is not a reliable indicator of perception. Another is that because turbidity and color are intercorrelated (R^2=.72 for our sample of sites) the two were confused in this question. In other words, respondents did not understand the distinction between color and turbidity. In hindsight it may have hindered the analysis to include both.

The presence of aquatic weeds is of minor importance. This may be due to the low incidences of eutrophication found in Boston's cold weather climate.

Table V-8

Importance of Various Water Quality Characteristics

Characteristic	Most Important		2nd		3rd		4th		Least Important	
Characteristic	#	%	#	%	#	%	#	%	#	%
a. color	39	8.4	73	15.6	78	16.7	145	31.0	110	23.6
b. odor	78	16.7	142	30.4	130	27.8	64	13.7	26	5.6
c. clearness	157	33.6	78	16.7	75	16.1	82	17.6	54	11.6
d. floating debris	157	33.6	115	24.6	80	17.1	56	12.0	28	6.0
e. aquatic weeds	15	3.2	38	8.1	76	16.3	88		217	46.5

1.5 Conclusions

In sum, the responses to these questions do not seem to support any hypothesis which relates recreation behavior to water quality. They suggest proximity is the most important determinant of a site choice. To the extent that improvements in water quality will open up beaches proximal to large numbers of people, the water quality improvement will lead to increased recreation benefits. This would be the case in many urban places, and particularly Boston.

A secondary conclusion is that recreation behavior is not overwhelmingly determined by socioeconomic variables. To a small extent higher levels of SES may reduce the sensitivity to distance and increase the propensity to visit the more distant, litter free beaches in a natural setting. Larger family size suggests a greater propensity to visit beaches where friends go.

Finally, the presence of facilities appears to be an important factor in site choice. If so, improvements in water quality should be accompanied by beach maintenance and capital investments to gain recreation benefits.

2. Public Perception of Water Quality

Do respondents agree on the quality of the water at individual sites? Does the public perception of water quality match the objective conditions? Which objective water qualith characteristics affect most strongly the respondent's perception of site conditions? These are the questions of this section.

The answers are the foundation for the demand models presented in Chapter VI. In particular, a link between perceived and objective water quality characteristics is a necessary but not sufficient condition to establish recreation benefits from water quality improvement.

2.1 Agreement Among Respondents

The first question presents the greatest analytical difficulties since there is at present no convenient methodology for assessing the degree of nominal scale agreement among multiple raters. There is a well-developed methodology for the case of two raters involving the kappa statistic but with more than two raters the only available approach appears to be to compute the full set of $\binom{n}{2}$ pairwise agreement statistics and to average them. This procedure can be applied when there is a small number of raters but it is manifestly impractical with several hundred raters.* Therefore, an informal analysis of the rating distribution must suffice. The distributions of water quality ratings for sites 1 to 29 are shown in Table V-9. With the exception of sites 6, 22 and 23, the distributions seem to be reasonably tight. Judging the degree of concensus by the percentage of total responses

*The problem of multiple raters is discussed in Fleiss [3] and Light [6]. Fleiss presents an application of the procedure described in the text to a case with six observers. This problem is also discussed briefly in Bishop et al [1].

Table V-9

Distribution of Ratings of Water Quality for 28 Sites

Site	# of Evaluations	% of Ratings in Category				
		1	2	3	4	5
1	24	12.5	29.2	29.2	16.7	12.5
2	44	15.9	34.1	31.8	15.9	2.3
3	98	9.2	17.3	33.7	27.6	12.2
4	119	37.0	29.4	22.7	8.4	2.5
5	10	20.0	20.0	30.0	20.0	10.0
6	13	23.1	15.4	15.4	38.5	7.7
7	14	42.9	28.6	7.1	14.3	7.1
8	27	25.9	44.4	18.5	3.7	7.4
9	7	14.3	28.6	42.9	14.3	0.0
10	9	22.2	33.3	33.3	0.0	11.1
11	11	18.2	18.2	54.5	9.1	0.0
12	12	16.7	33.3	41.7	8.3	0.0
13	13	30.8	38.5	23.1	7.7	0.0
14	5	20.0	20.0	40.0	20.0	0.0
15	41	34.1	29.3	26.8	9.8	0.0
16	124	4.8	12.1	28.2	30.6	24.2
17	57	0.0	3.5	12.3	40.4	43.9
18	86	3.5	3.5	11.6	45.3	36.0
19	45	6.7	13.3	26.7	35.6	17.8
20	28	3.6	3.6	21.4	21.4	50.0
21	18	0.0	5.6	16.7	38.9	38.9
22	34	26.5	14.7	23.5	14.7	20.6
23	23	26.1	34.8	21.7	0.0	17.4
24	18	50.0	16.7	22.2	5.6	5.6
25	24	8.3	16.7	29.2	33.3	12.5
26	46	4.3	17.4	23.9	34.8	19.6
27	8	37.5	12.5	12.5	25.0	12.5
28	20	20.0	15.0	30.0	20.0	15.0

NOTE: Rows sum to 100%, apart from rounding errors. The modal rating in each row is underlined. Site 29 was only rated by two respondents and is, therefore, omitted. (1=bad, 3=fair, 5=good) accounted for by the modal response, the concensus is somewhat greater, in general, for the sites with a higher modal water quality rating.

2.2 Accuracy of Perceptions

Given reasonably consistent ratings, the conceptually more important question of the accuracy of respondent's perceptions of water quality conditions can be considered. Before proceeding with this issue, recall that the yardstick for measuring the accuracy of public perceptions is the data obtained from our own water quality survey. Every effort was made to make these samples as representative as possible. With this caveat, consider Table V-10 which shows the correlation between water quality rating and the 16 objective measures of water quality. Negative correlations would be expected in all cases. With the exception of color, none of the correlations are statistically distinguishable from zero. The correlation between perceived water quality and color is only moderate, equalling -.377. The low correlation might, of course, be due to the delay in implementing the survey.

To obtain more detailed evidence on the accuracy of the respondents' perceptions of water quality and, at the same time, in order to examine the relative importance of different water quality parameters in the formation of people's perceptions of water quality, we regressed the water quality ratings for all sites on various objective water quality variables. There are some statistical problems with this procedure arising from the special nature of the dependent variable. Firstly, the water quality rating (RWQUAL) is a discrete variable; respondents were asked to rate sites on the integer scale from 1 to 5. Because ordinary least squares regression does not constrain the predicted value of the dependent variable to be an integer, it is more difficult to assess the true degree of association between the dependent and independent variables on the basis of the filled regression equation. Secondly, it is possible to argue that RWQUAL is not a cardinal but an ordinal variable: a person who rates

Table V-10

Correlations Between Water Quality Rating and Water Quality Variables

Variable	Correlation[+]
OIL	-.1100
JTU	-.0796
COLOR	-.3777*
PH	.1032
ALK	.0953
TPOS	-.1553
NITR	-.1044
AMMO	-.1752
COD	-.0136
COLI	-.1340
TBAC	-.0606
TEMP	-.2550
FACTOR 1	.1211
FACTOR 2	-.0516
FACTOR 3	-.1986
FACTOR 4	-.0385

[+]All figures are based on 29 observations (sites), those with an asterisk are significant at the 5% level.

a site at 4 certainly likes it more than a site which he rates at 2, but not necessarily twice as much more. Ordinary least squares is not a desirable technique for handling this type of dependent variable. Rather, it is preferable to use the maximum likelihood estimation procedure which is described below.

We start, however, with some OLS regressions of RWQUAL on selected water quality variables and the composit water quality factors. The results of these regressions are shown in Table V-11. It is clear that the water quality ratings are significantly affected by all the water quality parameters, except OIL. The slope coefficients for most variables have the signs which we would expect; the only exceptions are the coefficients of squared pH deviations from a neutral value of 7, and of temperature. The sign of the coefficient for temperature may be an artifact of the sample since inner-harbor sites are both warmer and more polluted than the more distant ones. The performance of the factor scores as explanatory variables is somewhat disappointing: on the whole, they do not perform any better than the water quality parameters to which they are related. Factor 3, the clarity factor, performs best as would be expected. The bacterial factor, Factor 4, also has an adequate t-statistic. Among the most important parameters for explaining water quality ratings are TURBIDITY, COLOR, PHOSPHORUS, AMMONIA, and COLIFORM and TOTAL BACTERIA.* The explanatory power of the individual equations is low, but this is partly to be expected because of the discreteness of the dependent variable. We are thus led to the conclusion that, while there is a significant connection between objective water quality conditions and the subjective water quality ratings, the degree of association between them does not appear to be very great.

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*The slope coefficients for TOTAL and COLIFORM BACTERIA appear somewhat similar and, indeed, when RWQUAL is regressed on both variables, the hypothesis that they have the same slope coefficient cannot be rejected.

Table V-11

Regression of Water Quality and Temperature Ratings on Water Quality Parameters

(984 observations)

Equation	R^2
RWQUAL = 3.057 + 0.00254 OIL (42.73) (0.36)	R^2=.000
RWQUAL = 3.256 - 0.0537 TURBIDITY (56.73) (4.88)	R^2=.024
RWQUAL = 3.41 - 0.0529 COLOR (48.57) (6.11)	R^2=.037
RWQUAL = 2.743 + 0.353 $(PH-7)^2$ (22.08) (2.76)	R^2=.008
RWQUAL = 2.834 + 0.00263 ALKALINITY (24.44) (2.25)	R^2=.005
RWQUAL = 3.499 - 7.6351 PHOSPHORUS (53.2) (8.18)	R^2=.064
RWQUAL = 3.096 - 0.3117 NITROGEN (72.44) (2.45)	R^2=.006
RWQUAL = 3.287 - 0.4665 AMMONIA (59.17) (5.67)	R^2=.032
RWQUAL = 3.244 - 0.00534 COD (42.84) (2.64)	R^2=.007
RWQUAL = 3.165 - 0.0000542 COLIFORM BACTERIA (64.19) (4.66)	R^2=.022
RWQUAL = 3.215 - 0.0000164 TOTAL BACTERIA (62.32) (4.53)	R^2=.021
RWQUAL = 8.162 - 0.0773 TEMPERATURE (7.95) (4.96)	R^2=.025
RWQUAL = 3.037 + 0.0976 FACTOR 1 (18.18) (2.02)	R^2=.004
RWQUAL = 3.059 - 0.0794 FACTOR 2 (71.82) (1.55)	R^2=.002
RWQUAL = 2.964 - 0.2995 FACTOR 3 (63.33) (4.89)	R^2=.024
RWQUAL = 3.054 - 0.1681 FACTOR 4 (72.18) (3.58)	R^2=.013
RTEMP = 0.13 + 0.04082 TEMPERATURE (0.12) (2.57	R^2=.007

A subsidiary issue, which can conveniently be analyzed in the regression context, is the question of whether respondent's from households which participated in boating or fishing might have a different perception of water quality than other respondents. This could be tested by adding a dummy variable for participation in these activities to the regression in Table V-11 but this would not necessarily be the best procedure, since there is no presumption that fishers or boaters rate sites higher or lower than the public at large. Rather, the presumption is merely that they rate sites differently from other people. To test this hypothesis, we conducted separate regressions of RWQUAL on COLOR and COLI for respondents from households which participated in boating and/or fishing and for respondents from households which do not.* In addition, we conducted a regression on the full posted sample. The regression results are as follows:

FISHERS/BOATERS (551 Observations)

RWQUAL = 3.353 - 0.033 COLOR - 0.0000449 COLI R^2=.037
(34.2)   (2.54)   (2.54)   F = 10.65
SSR= 989.46

NON-FISHERS/BOATERS (429 Observations)

RWQUAL = 3.501 - 0.06203 COLOR - 0.00000381 COLI R^2=.06
(35.54)   (4.45)   (0.21)   F = 13.68
SSR= 636.98

FULL SAMPLE POOLED (980 Observations)

RWQUAL = 3.415 - 0.0448 COLOR - 0.0000277 COLI R^2=.043
(48.91)   (4.70)   (2.16)   F = 22.16
SSR= 1632.09

---

*These explanatory variables were chosen as being among the most important in the single variable regressions. Another variable which we attempted to include is PHOSPHORUS, but it turned out that this variable is highly collinear with COLOR and COLI, and, therefore, it was dropped from the regression.

Applying the standard Chow test for the equality of interceptor and slope coefficients, we find that the hypothesis of homogeneity between fishers/boaters and others cannot be rejected.

2.3 Ordinal Rankings Considered

A maximum likelihood estimation technique can explicitly allow for the fact that the dependent variable may provide only an ordinal raking of sites. The logic of the model is as follows. It is assumed that the respondent's true sentiment towards recreation sites, W, is a function of certain variables, X, and a random disturbance (representing, perhaps, random differences in tastes).

$$W_i = X_i\beta + V_i. \qquad \ldots (1)$$

The variable, W, is a continuous, cardinal measure of preference. However we do not observe it directly, instead we observe a discrete, ordinal variable, Y, which is a function of W and of certain "threshold" parameters, t_1, t_2, t_3, t_4.

$$\begin{aligned} Y_i &= 1 \quad \text{if } W_i < t_1 \\ Y_i &= 2 \quad \text{if } t_i < W_i < t_2 \\ Y_i &= 3 \quad \text{if } t_2 < W_i < t_3 \\ Y_i &= 4 \quad \text{if } t_3 < W_i < t_4 \\ Y_i &= 5 \quad \text{if } W_i < t_4. \end{aligned}$$

The threshold parameters together with the coefficient vector β are to be estimated from the observed data on Y and X.

The model represented by (1) and (2) is flexible, in that it specifically enables a test of the assumption that Y is cardinal: if the estimated t_j are (approximately) the integers from 1 to 4 we may conclude that Y is approximately a cardinal measure; in these circumstances, the results from the OLS regressions presented above would indeed be adequate. Otherwise, these conclusions would not be warranted. The model is also plausible in that it corresponds to the way in which one intuitively thinks of rating site conditions; it seems quite likely that people's underlying sentiments towards the sites are cardinal in nature but are then mapped into a discrete, ordinal variable in the process of answering the questionnaire.

In order to estimate the model it is necessary to make some assumptions about the distribution of the random variable u in (1). It is convenient to assume that these variables are independently and identically distributed, having a common normal distribution with mean zero and variance σ^2. The resulting likelihood function is:

$$\mathcal{L}(\beta t|X,Y) = \prod_{Y_i=1} P\left[\frac{t_1-X_i\beta}{\sigma}\right] \cdot \prod_{Y_i=2} \left\{P\left[\frac{t_2-X_i\beta}{\sigma}\right] - P\left[\frac{t_1-X_i\beta}{\sigma}\right]\right\} \cdot \ldots$$

$$\ldots \prod_{Y_i=4} \left\{P\left[\frac{t_4-X_i\beta}{\sigma}\right] - P\left[\frac{t_3-X_i\beta}{\sigma}\right]\right\} \cdot \prod_{Y_i=5} \left\{1-P\left[\frac{t_4-X_i\beta}{\sigma}\right]\right\}$$

where $P[X]$ is the standard normal cumulative density function. In this model σ is not identifiable nor are all the threshold terms and the intercept in (1). As normalizations we take $\sigma=t_1=1$; with this assumption we can estimate both β and the differences (t_j-t_{j-1}) up to a multiplicative scale factor. The likelihood function is maximized by an iterative procedure which converged very rapidly in our experience.* Estimates of the variances and covariances of the coefficients are obtained from the Hessian of the likelihood function at the final iteration. From these estimates, the standard

*The convergence criterion criterion was that successive coefficient estimates must differ by less than .001 before the iteration stops. With our data this always happened by the sixth iteration.

t-test for significance can be derived since the computed test statistic asymptotically follows the t-distribution.

In order to implement the model, we focused on the relationship between the objective measures of color and coliform bacteria and subjective water quality relationships. The coefficient estimates are shown in the upper panel of Table V-12 (with the absolute value of the asymptotic t-statistic in parenthesis). It is noteworthy that the three bounded ranges are roughly (though not exactly) equally spaced, which tends to support the hypothesis that, at least in its middle range, RWQUAL is a cardinal measure. We can test the degree of association between the regressor variables and RWQUAL in at least two ways. The method is to compute the predicted scores using the estimated coefficients and see how many times the predicted score matches the actual score. The results of this test are very discouraging for the hypothesis of a strong correlation between objective site conditions and subjective perceptions: the predicted scores were all "1" ($\hat{W}$ ranged from -410 to -0.74), whereas only 155 of the 984 actual values of RWQUAL were 1. By this criterion, the model's fit is very poor. An alternative procedure to perform an analogue of the F-test in standard OLS regression to test the hypothesis is that the slope coefficients are jointly zero. For this purpose, we drop the regressor variables from the model while retaining the constant term and re-estimate the model. The resulting coefficient estimates are shown in Table V-12 in the lower panel. Although the likelihood function is lower for the second model than for the first, the difference is too small to be significant and hence we cannot reject the hypothesis that the slope coefficients are indeed zero.*

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*An alternative measure of association would be the multiserial correlation coefficient between the predicted value of W and the actual value of RWQUAL. See Cox [2].

Table V-12

Maximum Likelihood Estimates of Ordinally Discrete Dependent Variable Model

W = perceived water quality

$$W = \underset{(32.96)}{2.293} - \underset{(4.52)}{0.0353}\ \text{COLOR} - \underset{(2.21)}{0.00002328}\ \text{COLI BACT}$$

$$\text{RWQUAL} = 1 \quad \text{if } W < 1$$

$$= 2 \quad \text{if } 1 < W < \underset{(39.01)}{1.617}$$

$$= 3 \quad \text{if } 1.617 < W < \underset{(43.73)}{2.262}$$

$$= 4 \quad \text{if } 2.262 < W < \underset{(48.34)}{2.995}$$

$$= 5 \quad \text{if } W < 2.995$$

$$-\mathcal{L} = 1541.48$$

$$W = \underset{(41.46)}{2.002}$$

$$\text{RWQUAL} = 1 \quad \text{if } W < 1$$

$$= 2 \quad \text{if } 1 < W < \underset{(39.44)}{1.605}$$

$$= 3 \quad \text{if } 1.605 < W < \underset{(44.13)}{2.32}$$

$$= 4 \quad \text{if } 2.32 < W < \underset{(48.59)}{2.947}$$

$$= 5 \quad \text{if } W < 2.947$$

$$-\mathcal{L} = 1562.48$$

2.4 Conclusions

In sum, the hypothesis that water quality perceptions are not linked to actual water quality cannot be rejected on the basis of our data. Aside from data problems described elsewhere in this report, the most obvious explanation of this result is that human sensory perception of water quality is inaccurate. This is not a surprising conclusion, particularly for the "invisible" contaminants such as bacteria, algal nutrients, COD, etc. Perhaps our only perception of water quality occurs when a beach is closed by the health department. Alternately, this result may derive from some undiscovered peculiarity of our sample of raters. In any case, this conclusion jeopardizes the search for a link between levels of water quality and demand.

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VI. WILLINGNESS-TO-PAY

The willingness-to-pay survey method is frequently used for determining the value of public goods. This method, in essence, directly constructs a demand curve and its concomitant consumer surplus integral. Davis [3] pioneered the approach in the recreation research, and subsequently many researchers have applied it to the economics of water quality enhancement. Some of these studies are reviewed in Chapter II. Presumably, willingness-to-pay incorporates option demand and aesthetic benefits as well as the benefits from actual recreation.

Bias in benefit estimates from willingness-to-pay surveys are well known, but operate both to over- and under-state the goods' true value. The "free rider" problem suggests that willingness-to-pay will understate the true social value of the good. In the other direction, the fact that the willingness-to-pay debts will never come due could lead to extravagant estimates of value. To our knowledge, no research has adequately sorted out the relative magnitude of these effects.

Three questions were designed to elicit the willingness of respondents to pay for clean water for recreation:

WTP1

A. How much could the cost of visiting this site be raised before you started visiting your second most favorite site more:

a. $.50
b. $1.00
c. $2.00
d. $3.00
e. $4.00
f. $5-10.00
g. more than $10.00

WTP2

B. Suppose that this site were to become very polluted and the water quality would be reduced to a ranking of 1. This could be avoided if sufficient funds were raised to pay for the necessary clean-up. If these funds were to be raised through a higher entrance fee, how much would you be willing to pay to prevent this decline in water quality?

a. $.50
b. $1.00
c. $2.00
d. $3.00
e. $4.00
f. $5-10.00
g. more than $10.00

WTP3

C. Suppose that the water quality could be made much better (improved to a ranking of 5) if sufficient funds were raised to pay for the necessary clean-up. If these funds were to be raised through a higher entrance fee, how much would you be willing to pay to achieve the water quality improvement?

a. $.50
b. $1.00
c. $2.00
d. $3.00
e. $4.00
f. $5-10.00
g. more than $10.00

The analysis of these questions is in four parts. The first section below outlines the principal theoretical underpinning need for interpreting the responses to those questions. The next section analyzes the responses to the three questions via contingency tables. Mean willingness-to-pay is computed, and variations across subgroups of the sample are examined. Contingency tables are too restrictive to examine adequately the determinants of willingness-to-pay on the possible non-linear functional relationships involved. The third section uses OLS regression to probe these relationships more deeply. The final part of this chapter summarizes the major empirical findings and presents some benefit estimations based on these findings.

1. The Theoretic Basis for Willingness-to-Pay Calculations

Three measures of willingness-to-pay are available, corresponding to the three survey questions reproduced above. This brief and informal explanation of the theoretical infrastructure underlying these concepts is intended to define more precisely what these questions measure and the distinctions between them. A more formal analysis of willingness-to-pay (consumer surplus) and specification of the demand curve is presented in Chapter VII below.

The analysis starts with the individual's demand curve for a given site, which we assume to be a function of some measure of the cost of recreation at the site (including travel cost, entry fee, etc.); we use the blanket term "price" to refer to this variable. Temporarily ignoring the other variables which might affect the demand for the site, draw the individual's demand curve as a function of the price of the site; this curve is represented by the line DD' in Figure VI-1a. In this diagram, the recreationist is assumed to face a price of OP for visiting the site and, at that price, he makes OQ visits. Following the standard agrument of elementary micro-economic testbooks, we assert that the area OPDAQ may be taken as an approximate measure of the consumer's total benefit from making OQ visits to the site, the area OPAQ measures his expenditures for visiting the site, and the area PDA may be taken as an approximate measure of his net benefit (consumer's surplus) from visiting the site OQ times. This last area is (approximately) the maximum additional amount which the individual would be willing to pay for visiting the site OQ times rather than not at all.

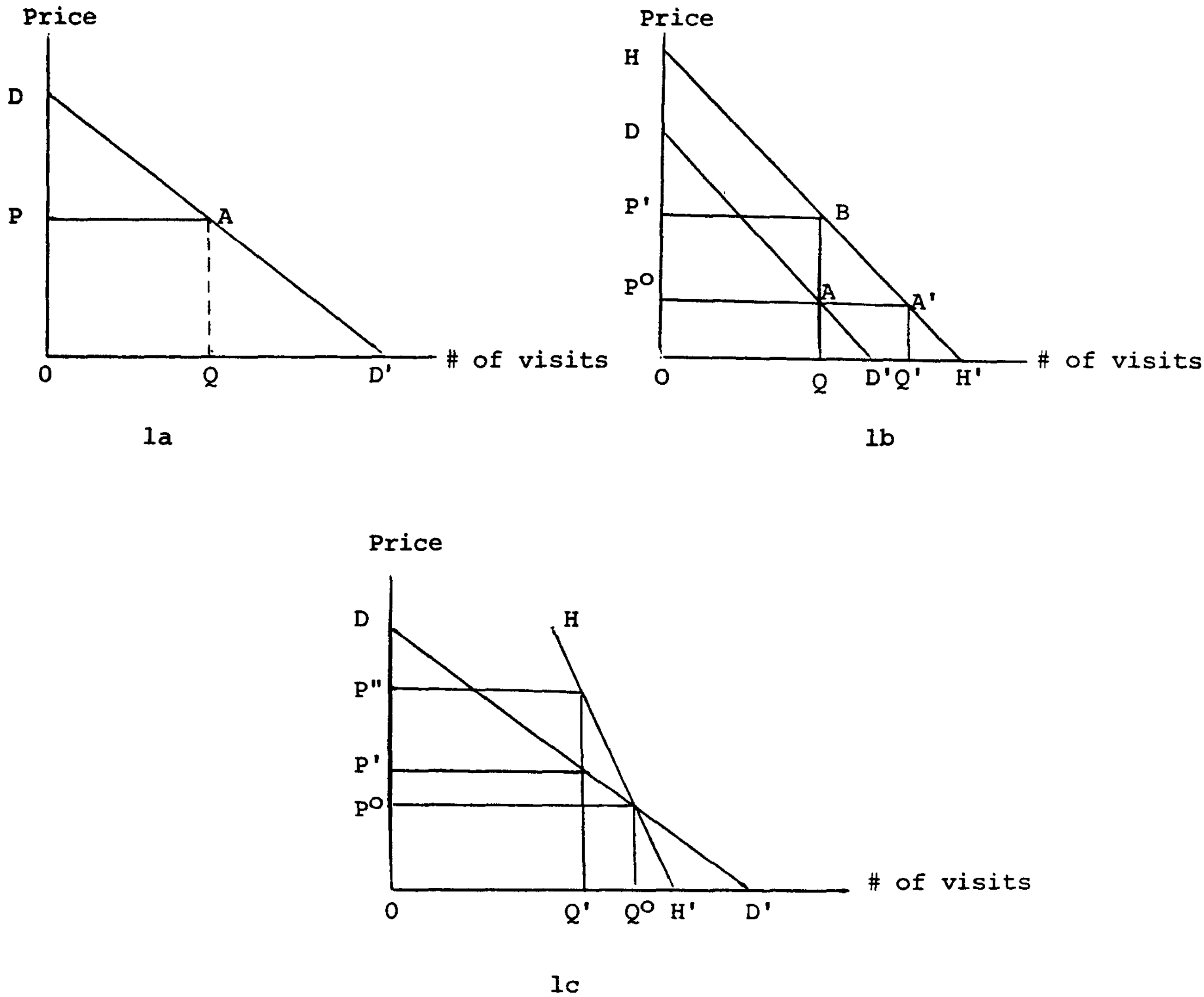

Figure VI-1: Demand Curves for an Individual Recreation Site

What can be said about the determinants of this area? Holding all other variables constant, it is larger when the price of the site is lower (and the number of visits to the site larger). It will also be affected by variables which shift the demand curve DD' holding price constant. Thus, if recreation at the site is a normal good and the individual's income rises, the demand curve would shift outwards. This is illustrated in Figure VI-1b. If the individual's income rises (or if we are comparing two individuals, one having a larger income than the other) the demand curve changes from DD' to HH'; with price constant at OP, the net benefit increases, the amount of the increase being the area ADHBA'. Similarly, if some alternative site which the individual might visit as a substitute declines in quality, we would expect the individual's demand for this site to increase and, with it, net benefit. Finally, if the quality of this site itself is upgraded, we would expect his demand to increase; assuming his demand curve shifts from DD' to HH' we may take the area as an approximate measure of his net benefit from the improvement in quality. Conversely, if the site's quality declines and if the initial demand curve is taken to be HH', this area is a measure or approximate measure of the disbenefit arising from the quality change. Probably it is a function of the magnitude of the quality change, but not necessarily of other variables. However, it is possible that this area is a function of the <u>initial</u> level of water quality or the initial number of visits (if we assume, say, a declining marginal utility of water quality) and it is not inconceivable that it is also a function of income (if we assume that the marginal utility of site quality is not constant with respect to income). Nevertheless it is quite possible that these variables might not affect the magnitude of the net benefit for water quality changes.

With this background, we can consider more precisely what the willingness-to-pay questions measure using Figure VI-1b. Consider the last measures, WTP3, the value of achieving water quality increases is assessed. Here we ask the respondent to tell us the maximum he would pay (i.e., P^oP') to move his demand curve from DD' to HH' (and implicity still consume OQ units of recreation). His net benefit before and after the shift must be equal (or else he would be willing to pay more) so the areas P'BH and P^oAD must be equal. The net benefit he would receive if water were improved and the charges not levied is, therefore, $P^oA'BP'$. This quantity is proportional to P^oP' and an estimate which understates its magnitude is given by P^oABP'. Of course, this analysis assumes the demand curves are approximately linear over the range considered and that DD' and HH' are parallel. Note that the parallel shift assumption is the more critical one for recovering reasonable approximations to the change in net benefits from the willingness-to-pay questions.

Ideally, we would like to determine the willingness-to-pay over the entire season rather than the willingness-to-pay per visit and then an exact measure of net benefit would be available. But, the former is manifestly unreliable in a survey research context. For any respondent, willingness to pay over the whole season can be estimated by multiplying the reported willingness-to-pay by number of the current visits. WTP2, the value of avoiding water quality declines can be derived similarly.

Figure VI-1c has been constructed to help analyze the first willingness-to-pay question, WTP1. This question asks how much the cost per visit could be increased before the number of visits declines, not necessarily to zero, but to some smaller number, and the best substitute for that site is visited more often. When perfect substitutes are available, consumers' surplus vanishes. This question in effect uses the implicit rates of substitution between the two more preferred sites to compile the net benefit of the most preferred site.

If the consumer is presently visiting the site Q^o times, we assume that if he visits it less he visits it Q' times where Q^o-Q' is some integer (not necessarily unity) which depends on the relative attractiveness of this site and the second most favorite site. The situation is depicted in Figure VI-1c for two different demand curves, DD' and HH'. Suppose, first, that the true demand curve is DD'; with price P^o, the individual makes Q^o visits. The question, in effect, asks for the maximum length $(P'-P^o)$ such that if price increased to P', the individual would begin to reduce the number of his visits.

The change in net benefit from this change in price and consumption equals P^oQ^oBP'. In general, this area depends on the magnitude of the "minimum required reduction" Q^oQ', which is unknown to us. Assume the reduction is small (i.e., Q^oQ' equals unity) which is not implausible given the wording of the question. Then the change in net benefit is bounded above by the quantity $(P^oP')\cdot Q^o$, the reported willingness-to-pay multiplied by number of visits prior to the price increases.

Observe that the net benefit depends strongly on the slope of the demand curve. To see this compare the demand curves DD', and HH' in Figure VI-1c. With the latter demand curve, the same starting amount, and "minimum required reduction," the answer to our question would be P^oP'', a considerably larger amount than P^oP'. But under those conditions, and assuming that the demand curve is linear over this range, then the percent error in the net benefit estimate does not depend on the slope of the demand curve.

We hypothesize that the magnitude of the price increase ($P^{o}P'$ or WTP1) is positively related to the respondents household income and the quality of the site, and negatively to the price of visiting the site (measured by, say, travel time or distance). It may be positively or negatively related to the total number of visits to the site and the total number of visits to other sites.

2. Tabular Analysis of Willingness-to-Pay

The responses to the willingness-to-pay questions are presented in Table VI-1. Several results from this table are of interest. First, the mean values of willingness-to-pay is greater than zero (significant at the 5% level) for all three measures. In other words, despite their inaccurate perception of water quality, respondents were willing to pay to avoid it. This suggests that the principal benefits of water quality improvements are essentially "conservation" oriented rather than "use" oriented.

Second, the incremental value of the favorite site over the second site is less than the value of either avoiding water pollution or achieving water quality improvements (the difference is not, however, statistically significant at the 5% level). Since to avoid the water quality deterioration, the person could shift to the second site and not pay the added cost, this difference reinforces the hypothesized non-usage (merit good, latent demand, option demand, or aesthetic) benefit of water quality improvement. In fact, since we have found only tenuous, at best, support for the relationship between water quality and recreation behavior, we might speculate that most of the willingness-to-pay is in these categories.

The third result is that willingness-to-pay is symmetric between avoiding declines and achieving improvement in water quality. A three-way contingency table shows a strong correlation between response to WTP2 and WPT3 (i.e., the hypothesis of independence can be rejected at the 5% level). This is not unexpected in survey research. Furthermore, the distribution means for WTP2 and WTP3 are nearly identical and the standard deviation differs only by 1.1%, largely because most respondents answered the questions identically. This similarity suggests two hypotheses: either tastes are symmetric and the water quality

TABLE VI-1

Distribution of Willingness to Pay
($ per visit)

	Question					
	WTP1		WTP2		WTP3	
	#	%	#	%	#	%
$ .50	128	36.0	86	25.4	84	24.8
$1.00	84	24.0	113	33.3	113	33.3
$2.00	68	19.4	67	19.8	70	20.6
$3.00	26	7.4	26	7.7	27	8.0
$4.00	17	4.9	14	4.1	14	4.1
$5-10	16	4.6	24	7.1	21	6.2
> 10	13	3.7	9	2.7	10	2.9
Median	1.083		1.239		1.237	
Mean	1.978		2.077		2.034	

rating equals 2.5 or tastes are nonsymmetric to account for water quality ratings different from 2.5. As seen in Section IV 2.3 above, the mean water quality rating equals 2.881, and is slightly skewed to the right. A rating of 2.5 is not statistically different (at 5% confidence) from the observed mean. Combined with the symmetry of response to questions WTP2 and WTP3, the difference suggests avoiding water quality declines is not so valuable as achieving water quality improvements. This is contrary to the expressed preferences which associated (negatively) site choice only with bad water quality and find little if any response to good water quality. Again, we must conclude that these willingness-to-pay questions measure something outside recreational usage.

Previous studies have found willingness-to-pay for water quality improvement to be related to income and education. Our analysis is more limited, being confined to the recreation context, but we still would expect a positive correlation between willingness-to-pay and income, education and occupation. Too, we expected whites to have higher levels of willingness-to-pay than blacks. None of these hypotheses were confirmed at the 5% level.* No S-shaped curve between income and willingness-to-pay, as suggested by some authors could be discerned from the tables. A significant positive correlation was found between family size and willingness-to-pay, but this relationship disappeared when willingness-to-pay was computed on a per capita basis.

This absence of correlation was surprising. Since our sample SES characteristics are close to those for the SMSA as a whole, these results suggest that the willingness-to-pay is uniform across the population. The individual amounts are small, so perhaps they do not constitute an adequately large portion of total income to induce any differential effect.

*The next section probes these relationships in greater depth.

Alternatively, in general, the poorer group of our sample live closer to the lower quality inner city beaches. Conversely, the more wealthy visit the better quality outer beaches more often. Since there was substantial agreement concerning the perceived water quality across the sites, we could postulate that the poor are willing to pay more in proportion to their income than the wealthy because they currently visit poorer sites and would like to see them improve. However, then the wealthy should be willing to pay more to avoid declines in their good sites and a positive income correlation with WTP2 should exist. But no such correlation was found. Bolstered by the regression analysis in Section 3, Section 4 of this chapter returns to these conclusions.

A second set of hypotheses were formulated to examine the relationship between willingness-to-pay and access to recreation. Access included ownership of an automobile, amount of leisure time each week, amount of vacation time per year, total amount of recreation equipment owned and the use of public transit. We expected auto ownership to be negatively correlated and all the others positively with willingness-to-pay. At the 5% level, only transit usage was significant as shown in Table VI-2. Frequent users of public transit may not have access to high quality sites, and, therefore, perceive greater benefits from water quality improvements and disbenefits from declines.

The last subgroup examined were participants in various activities. We hypothesized that participants would be more sensitive to water quality benefits than non-participants. For swimmers, boaters, walkers and bicyclists, the hypothesis was not proved. For fishermen, the hypothesis can be accepted at a 5% level of confidence, and the contingency table is shown in Table VI-3.

Table VI-2

Willingness to Pay By Transit Usage

	Transit Use			
	Never	Almost Never	Occasionally	Frequently
a. $.50	(12) 14.1 18.2	(14) 16.5 19.2	(7) 8.2 12.1	(52) 61.2 36.9
b. $1.00	(23) 20.4 34.8	(27) 23.9 37.0	(27) 23.9 46.6	(36) 31.9 25.5
c. $2.00	(11) 16.4 16.7	(20) 29.9 27.4	(11) 16.4 19.0	(25) 37.3 17.7
d. $3.00	(7) 26.9 10.6	(5) 19.2 6.8	(6) 23.1 10.3	(8) 30.8 5.7
e. $4.00	(1) 7.1 1.5	(2) 14.3 2.7	(3) 21.4 5.2	(8) 57.1 5.7
f. $5-10.00	(11) 45.8 16.7	(3) 12.5 4.1	(2) 8.3 3.4	(8) 33.3 5.7
g. more than $10.00	(1) 11.1 1.5	(2) 22.2 2.7	(2) 22.2 3.4	(4) 44.4 2.8

Table shows cell count in ( ), row percentages and column percentages.

Table VI-3

Willingness to Pay by Participation in Fishing

	1	2	3	4	5	6	7
1. Fishermen	(40) 28.2 31.7	(39) 27.5 46.4	(26) 18.3 38.2	(16) 11.3 61.5	(9) 6.3 52.9	(5) 3.5 31.3	(7) 4.9 53.8
2. Non-Fishermen	(86) 41.3 68.3	(45) 21.6 53.6	(42) 20.2 61.8	(10) 4.8 38.5	(8) 3.8 47.1	(11) 5.3 68.8	(6) 2.9 46.2

Table shows cell count in ( ), row percentages and column percentages.

3. Regression Analysis of Willingness to Pay

For ordinary least squares regression analysis, it is convenient to continuous variables for both the dependent variable--willingness to pay--and the independent variables. This assumption is not strictly necessary--we shall relax it partially below--but it greatly simplifies the analysis and it seems to be fairly reasonable in the present case. The answers to the willingness to pay questions are essentially ranges: the respondent who checks response (d)--$3--may be presumed to be actually willing to pay some amount greater than $2.50, but less than $3.50, and similarly with the other responses. Nevertheless, the ranges are relatively small, and therefore it is not unreasonable to use the midpoints of the ranges in place of the unknown means. A similar argument applies to the income variable. In doing this we arbitrarily take the (unknown) midpoint of the last willingness to pay answer--"more than $10--to be $15 and with the income variable we take the midpoint of the first income class to be $2,500 and that of the last class to be $60,000.*

The properties of the resulting estimator have been analyzed by Haitovsky [4]. He shows that they are biased in general, but if the number of categories into which the dependent variable is classified is the same as the number of categories into which the explanatory variable is classified, the resulting estimator will be the same as that obtained by using the (unknown) means of the ranges instead of the midpoints. Cramer [2] has shown that the latter estimator is unbiased, although inefficient. Haitovsky [4] also shows that when the number of categories for the explanatory variable is larger than for the number for the dependent variable--

*These values are actually closer to the mean of the first and last groups computed from a Pareto distribution.

as is the case when we regress willingness to pay on income--the slope coefficient obtained by using the midpoints is likely to be larger in absolute value than that obtained by using the means. In addition, he shows that the loss of efficiency due to grouping declines as the category size is smaller and as the population correlation between the dependent and independent variable approaches unity.

The other issue which we must address is the functional form of the relationship between willingness to pay and its determinant. We had no reason a priori to prefer any particular form. We therefore considered several different functional forms, including the following:

I	$\frac{1}{y} = a + b/x.$	$\varepsilon_{yx} = \frac{b}{(ax + b)}$
II	$\ln y = a - b/x$	$\varepsilon_{yx} = b/x$
III	$\ln y = a + bx$	$\varepsilon_{yx} = bx$
IV	$\ln y = a + b \ln x$	$\varepsilon_{yx} = b$
V	$y = a + b \ln x$	$\varepsilon_{yx} = \frac{b}{y}$
VI	$y = a + bx$	$\varepsilon_{yx} = \frac{bx}{y}$

where $\varepsilon_{yx} = \frac{dy}{dx}\left(\frac{x}{y}\right)$ is the elasticity of y with respect to x.

Form I, with b<0, is an  shaped function, intercepting the x-axis at zero and approaching 1/a asymptotically as x increases to infinity. Form II with b>0 is an  shaped function, passing through the origin and approaching (a) asymptotically as x increases to infinity. Form III with b>0 is an  shaped function, cutting the y-axis at a. Form V with b>0 is shaped rather like Form I, except that it cuts the x-axis at $e^{-a/b}$ and increases without bound as x increases. The shapes of the other two functions require no explanation. When necessary, an appropriate criterion for choosing among alternatives II, III and IV, or between V and VI is minimizing the residual sum of squares from the fitted regression--or, equivalently, maximizing the R^2 statistic. However, in order to choose between the three broad classes of functions (I), (II, III, IV), (V, VI), with respectively $1/y$, $\ln y$ and y as the dependent variable, it is necessary to apply the likelihood ratio test suggested by Box and Cox [1].

As before, we refer to the additional willingness to pay for visiting the respondent's favorite site as WTP1, the willingness to pay to prevent the site from becoming polluted as WTP2, and the willingness to pay to obtain a higher level of water quality as WTP3. Since these three measures pertain to different concepts, there is no reason why they should be identical in value. In order to test this, we regress one measure on the other; if the two measures were identical, the estimated intercept would not be significantly non-zero and the estimated slope coefficient would not be statistically different from unity. The regressions are performed on the data subsets containing answers to both questions, for each of the three pairs of measures. The results are as follows:[1]

$$\underset{}{WTP2} = \underset{(5.88)}{1.031} + \underset{(11.73)}{0.5715}\ WTP1 \qquad R^2 = .335 \qquad (275\ \text{obs.})$$

$$WTP3 = \underset{(5.94)}{0.983} + \underset{(12.48)}{0.547}\ WTP1 \qquad R^2 = .362 \qquad (277\ \text{obs.})$$

$$WTP3 = \underset{(2.55)}{0.248} + \underset{(31.4)}{0.8662}\ WTP2 \qquad R^2 = .772 \qquad (293\ \text{obs.})$$

[1]The numbers in parentheses below the coefficient estimates are t-statistics.

Clearly, WTP2 and WTP3 are closer in value to each other than to WTP1, but no pair of these measures is sufficiently close to be considered statistically identical.[1]

Determinants of WTP1

On the basis of the considerations outlined in Section 1, we hypothesize that WTP1 is a positive function of income (INC), a negative function of travel time (TIME) and distance to the site (DIST), which are a large component of the site's "price", a positive function of the household's total number of visits to the site (HVS), and a positive function of the site's quality. For the last variable we can use either the respondent's subjective rating of the site's characteristics or the "objective" water quality characteristics.

The results of some bivariate regressions are shown in Table VI-4. It turns out that there is little relationship between willingness to pay and income. The two preferred equations--one of them representing an S-shaped relationship--indicate that the relationship is significant at the 90%, but not the 95% level. As hypothesized, there is a positive relationship between the number of visits and willingness to pay. Willingness-to-pay and travel time or distance, which may be taken as proxies for price, are also positively associated, an unexpected result. We discuss this result in greater detail below.

The next three sets of regressions show that there is a strongly significant relationship between willingness-to-pay and

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*In fact, our of the 293 cases where the respondent provided data on both WTP2 and WTP3, the response was the same in 251 cases; in 24 cases WTP3 exceeded WTP2 and in 18 cases WTP2 exceeded WTP3.

All the intercepts are significantly different from zero, and slope coefficients are less than unity at the 95% level.

Table VI-4

Some Regressions with WPT1 as Dependent Variable

INCOME (256 observations)			
* FORM I.	1/WTP1 = 0.9854 + 988.47/INC (13.37) (1.78)	R^2=.012	f=3.12
* FORM II.	ln(WTP1) = 0.3672 - 1177.28/INC (1.64)	R^2=.01	f=2.68
FORM IV.	ln(WTP1) = -1.017 + 0.1343ln(INC) (1.19) (1.49)	R^2=.009	f=2.21
HOUSEHOLD VISITS TO SITE (308 observations)			
FORM V.	WTP1 = 1.57 + 0.3114ln(HVS) (4.63) (2.01)	R^2=0.13	f=4.05
* FORM VI.	WTP1 = 1.92 + 0.0191 · HVS (9.33) (2.05)	R^2=.013	f=4.19
DISTANCE FROM SITE (290 observations)			
FORM I.	1/WTP1 = 1.02 + 0.1535/DIST (19.12) (1.74)	R^2=.01	f=3.02
* FORM VI.	ln(WTP1) = 0.029 + 0.0274 · DIST (0.38) (3.87)	R^2=.049	f=14.95
FORM VI.	ln(WTP1) = 1.767 + 0.0442 · DIST (7.07) (1.92)	R^2=.013	f=3.67
TRAVEL TIME (293 observations)			
FORM I.	1/WTP1 = 0.979 + 1.395/TIME (16.7) (1.79)	R^2=.011	f=3.19
* FORM IV.	ln(WTP1) = -0.405 + 0.2066ln(TIME) (1.93) (3.38)	R^2=.038	f=11.43
FORM VI.	WTP1 = 1.82 + 0.00995TIME (7.12) (2.13)	R^2=.015	f=4.52
RATING OF WATER QUALITY (303 observations)			
FORM I.	1/WTP1 = 0.8441 + 0.519/RWQUAL (11.52) (3.50)	R^2=0.39	f=12.27
* FORM III.	ln(WTP1) = -0.2105 + 0.1485 · RWQUAL (1.59) (3.97)	R^2=.05	f=15.78
FORM VI.	WTP1 = 1.141 + 0.3223RWQUAL (2.63) (2.63)	R^2=.022	f=6.91
RATING OF BEACH QUALITY (303 observations)			
FORM I.	1/WTP1 = 0.9085 + 0.4698/RBQUAL (11.85) (2.48)	R^2=.02	f=6.13
* FORM II.	ln(WTP1) = -0.295 + 0.1535RBQUAL (1.85) (3.67)	R^2=.043	f=13.46
FORM IV.	WTP1 = 0.761 + 0.3881RBQUAL (1.46) (2.85)	R^2=.026	f=8.1

Table VI-4 (CONTINUED)

Some Regressions with WPT1 as Dependent Variable

RATING OF CROWDING (308 observations)

FORM I. 1/WTP1 = 0.965 + 0.2273/RCROWD — R^2=.008 f=2.51
(12.67) (1.59)

* FORM III. ln/WTP1) = -0.0197 + 0.094RCROWD — R^2=.019 f=5.82
(0.15) (2.41)

FORM VI. WTP1 = 1.296 + 0.2906RCROWD — R^2=.017 f=5.35
(2.31)

FACTOR 4 (245 observations)

FORM I. 1/WTP1 = 1.0277 - 0.00924/FACT4 — R^2=.016 f=3.91
(21.48) (1.98)

* FORM II. ln(WTP1) = 0.2943 + 0.0129/FACT4 — R^2=.019 f=4.83
(4.9) (2.2)

FORM VI. WTP1 = 2.131 + 0.5088 · FACT4 — R^2=.021 f=5.33
(2.31)

pH (245 observations)

FORM I. 1/WTP1 = 1.033 + 0.0125/pH — R^2=.008 f=1.96
(20.92) (1.4)

* FORM II. ln(WTP1) = 0.2902 - 0.0186/pH — R^2=.011 f=2.76
(4.68) (1.66)

TURBIDITY (187 observations)

* FORM I. 1/WTP1 = 0.965 + 0.5268/TURB — R^2=.059 f=11.57
(12.24) (3.4)

FORM IV. • ln(WTP1) = -0.24 + 0.2822ln(TURB) — R^2=0.72 f=14.38
(3.15) (3.79)

FORM VI. WTP1 = 1.101 + 0.1468 · TURB — R^2=.052 f=10.23
(3.79) (3.2)

COLIFORM BACTERIA (245 observations)

* FORM III. ln(WTP1) = 0.2036 + 0.0000341 · CBACT — R^2=.014 f=3.37
(3.33) (1.84)

FORM VI. WTP1 = 1.8802 + 0.0000135 · CBACT — R^2=.022 f=5.56
(9.99) (2.36)

NOTES:
1. The absolute values of the t-statistic are given in parentheses below the coefficient estimates.
2. The critical values at the 95% level for the t- and f-statistics are respectively 1.96 and 3.84.
3. An asterisk denotes the functional form which is preferred on the basis of the likelihood ratio test.

perceived site quality, as measured by the rating of water quality, beach quality and crowding.* However, the relationship between willingness to pay and "objective" water quality is tenuous at best. Many objective water quality measures, such as the sites' scores for Factors 1, 2 and 3 and such variables as alkalinity and color bear no significant relationship to willingness to pay. Those variables which do have a significant slope coefficient, such as pH (measured in terms of squared deviations from the value of 7), turbidity and coliform bacteria, have a positive coefficient instead of a negative one (it should be remembered that larger values of these variables signify a greater degree of pollution). The only exception is the site scores for Factor 4 (which are positively correlated with bacteria counts); the regressions equation using Forms I and II indicate a significant negative relationship with willingness to pay, while the equation using Form VI indicates a significant positive relationship. This last result is difficult to interpret since it is unlikely that recreationists can perceive bacteria, let alone a composite water quality factor which loads heaving on the bacteria count.

The divergence between the results obtained using subjective ratings of site characteristics and objective measures of water quality reaffirm one's doubts concerning the accuracy of the respondent's perception of water quality conditions at the Boston area sites.

There remains the question of the positive slope coefficient in the regressions of WTP1 on TIME and DIST. Larger values of these variables, signifying a higher cost of access to the site, and should be associated with smaller amounts of willingness to pay. One explanation for the positive slope coefficients is that the more distant sites are of a better quality than the closer sites, so that distance is serving as a proxy for site quality. That this

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*These variables are here treated as being continuous, cardinal variables. The appropriateness of this assumption was discussed more fully in Section V 2.3, above.

explanation has some validity is shown by the correlation coefficients between distance and various site quality variables displayed in Table VI-5. * In order to examine the relationship between willingness to pay and distance, allowing for the separate effects of site quality, consider these regressions of WTP1 on both distance and quality variables:**

$$\ln(WTP1) = \underset{(1.9)}{-0.323} + \underset{(.69)}{0.0301}\ DIST + \underset{(3.89)}{0.1617}\ RWQUAL \qquad R^2 = .066 \qquad F = 9.03$$

$$\ln(WTP1) = \underset{(1.51)}{-0.288} + \underset{(.73)}{0.0329}\ DIST + \underset{(2.73)}{0.1328}\ RBQUAL \qquad R^2 = .039 \qquad F = 5.18$$

$$\ln(WTP1) = \underset{(2.07)}{-0.296} + \underset{(1.59)}{0.0024}\ TIME + \underset{(3.62)}{0.1509}\ RWQUAL \qquad R^2 = .073 \qquad F = 10.123$$

$$\ln(WTP1) = \underset{(1.64)}{-0.289} + \underset{(2.07)}{0.0031}\ TIME + \underset{(2.69)}{0.1253}\ RBQUAL \qquad R^2 = .053 \qquad F = 7.13$$

It seems from these regression equations that, even when the effects of site quality are removed, there is still a somewhat positive relationship between willingness to pay and distance. The same conclusion holds when income, which is positively correlated with both distance and willingness to pay, is held constant, as can be seen from the following regressions:***

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*These correlation coefficients are computed from the full set of data on household visits to all sites, rather than merely the visits to the favorite site.

**These regressions are based on 260 observations; the notation and display is the same as in Table VI-1.

***These regressions are based on 226 observations.

Table VI-5

Correlation of Time and Distance Travelled to 29 Sites With Site Quality Variables

	TIME	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	Bacteria	Color	Turbidity	Rating of Water Quality	Rating of Beach Quality	Rating of Crowding	Household Income
Distance	.453	.218	-.093	-.214	-.210	-.304	-.347	-.263	.395	.202	.278	.125
In (Distance)	.407	.208	-.129	-.232	-.235	-.347	-.376	-.275	.371	.185	.252	.155
Time	1.000	.087	-.099	-.130	-.109	-.179	-.148	-.135	.110	.072	.119	.053

NOTE: "Bacteria" is the arithmetic mean of Coliform and Total Bacteria.

All the correlation coefficients are significantly different from zero at the .01 level; there are about 900 degrees of freedom for all but the last column, for which there are about 750 degrees of freedom.

$$\ln(WTP1) = \underset{(1.31)}{-0.242} + \underset{(1.56)}{0.0139}\ DIST + \underset{(2.69)}{0.1301}\ RWQUAL - \underset{(.48)}{353.15}/INC$$

$$R^2 = .076 \qquad F = 6.1$$

$$\ln(WTP1) = \underset{(1.31)}{-0.242} + \underset{(1.56)}{0.0024}\ TIME + \underset{(3.12)}{0.1422}\ RWQUAL - \underset{(.71)}{520.18}/INC$$

$$R^2 = .076 \qquad F = 6.1$$

Thus, it seems possible that respondents place a positive premium on more distant sites, even when the effects of site quality and income are removed. There are two possible explanations for this phenomenon. The most obvious explanation is that respondents visit those sites for their natural setting, lack of crowding, or other site characteristics not included. Another explanation is based on the specialized definition of the WTP1 variable, discussed in Section 1 above; it may be that the length (Q^0-Q^1) in Figure VI-1c is larger for more distant sites than for nearer sites; that is, if the household is to reduce the number of its visits to its favorite site, the minimum reduction is larger for more distant sites. The alternative explanation is that recreation sites, like certain other commodities, may be subject to the Veblen effect: consumers are willing to buy larger quantities of the higher priced good.

Determinants of WTP2

The results of some regressions of WTP2 on various explanatory variables are shown in Table VI-6. Willingness to pay to avoid very polluted site condition appears to be an increasing function of income, although the confidence intervals on this result are wide. Also, increases in present site conditions tend to increase WTP2. From the fact that functional form III has the best fit of all six forms, we may infer that willingness to pay elasticity actually increases with quality of present site conditions, which refutes the diminishing marginal utility of water quality hypothesis

Table VI-6

Some Regressions with WTP2 as Dependent Variable

INCOME (247 observations)

I. $1/WTP2 = 0.8492 + 1253.57 \cdot 1/INC$ R^2=.033 f=5.42
(12.26) (2.33)

III. $\ln(WTP2) = 0.185 + .00001113 \cdot INC$ R^2=.013 f=3.3
(1.7) (1.82)

IV. $\ln(WTP2) = -1.1571 + .1602 \ln(INC)$ R^2=.013 f=3.2
(1.37) (1.79)

RATING OF WATER QUALITY (292 observations)

I. $1/WTP2 = 0.825 + 0.3828/RWQUAL$ R^2=.025 f=7.32
(11.68) (2.7)

III. $\ln(WTP2) = -0.0549 + .1188 \cdot RWQUAL$ R^2=.034 f=10.32

IV. $\ln(WTP2) = 0.05083 + 0.26581n(RWQUAL)$ R^2=.027 f=8.05
(.46) (2.84)

RATING OF BEACH QUALITY (294 observations)

I. $1/WTP2 = 0.8109 + 0.529/RBQUAL$ R^2=.032 f=9.96
(11.39) (3.11)

III. $\ln(WTP2) = -0.162 + 0.1319 \cdot RBQUAL$ R^2=.037 f=11.1
(1.08) (3.33)

IV. $\ln(WTP2) = -0.0338 + 0.291n(RBQUAL)$ R^2=.025 f=7.36
(.25) (2.71)

PARTICIPATION IN FISHING/BOATING (303 observations)

III. $\ln(WTP2) = 0.209 + 0.2094PART$ R^2=.014 f=4.26
(2.80) (2.06)

VI. $WTP2 = 1.838 + 0.6497PART$ R^2=.014 f=4.16
(7.85) (2.04)

DISTANCE/TIME, WATER QUALITY RATING AND INCOME (226 observations)

III. $\ln(WTP2) = -1.113 + 0.0116DIST + 0.0815RWQUAL + 0.1171n(INC)$ R^2=.05
(1.29) (1.29) (1.72) (1.25) f=3.92

III. $\ln(WTP2) = -1.276 + 0.000794TIME + 0.1014 RWQUAL + 0.13441n(INC)$ R^2=.045
(1.49) (0.51) (2.28) (1.46) f=3.46

suggested above. In addition, we have regressed WTP2 on a dummy variable PART, which takes the value 1 of members of the respondents' household engaged in boating and/or fishing, and the value 0 otherwise. As we might expect, participation in these activities increases the respondent's willingness to pay to avoid pollution by about 20% over nonparticipants. Finally, as with WTP1, there is some evidence of a positive relationship between distance and willingness to pay, even when water quality rating and income are held constant.

Determinants of WTP3

The results of some regressions of WTP3 on several explanatory variables are shown in Table VI-7. The most important finding is that willingness to pay to obtain an improvement in water quality increases with present site quality. This is completely counterintuitive: we had hypothesized that willingness to pay would be greatest when existing site conditions were very poor, because visitors to such sites would have the greatest amount to gain, both absolutely and relative to the starting position. The finding that the reverse seems to be true suggests that the taste for water quality increases with the respondent's exposure to it. In terms of utility theory, we are suggesting that the marginal utility of water quality may increase with "consumption" of water quality, at least within the range covered by the present sample.

Table VI-7

Regressions with WTP3 as Dependent Variable

INCOME (247 observations)

I.	1/WTP3 = 0.9007 + 736.33/INC (12.97)	R^2=.008	F=1.87
III.	ln(WTP3) = 0.2878 + 0.00000344 INC (2.71) (.57)	R^2=.001	F=0.33
IV.	ln(WTP3) = -0.1737 + 0.0544ln(INC) (.21) (.62)	R^2=.002	F=0.38

RATING OF WATER QUALITY (292 observations)

I.	1/WTP3 = 0.819 + 0.3544/RWQUAL (11.77) (2.61)	R^2=.023	F=6.81
III.	ln(WTP3) = 0.0093 + 0.1023 RWQUAL (.07) (2.82)	R^2=.027	F=7.97
IV.	ln(WTP3) = 0.1058 + 0.2229ln(RWQUAL) (1.0) (2.46)	R^2=.02	F=6.03

RATING OF BEACH QUALITY (295 observations)

I.	1/WTP3 = 0.7908 + 0.5281/RBQUAL (11.38) (3.24)	R^2=.035	F=10.5
III.	ln(WTP3) = -0.088 + 0.116 RBQUAL (.60) (2.98)	R^2=.029	F=8.87
IV.	ln(WTP3) = 0.0171 + 0.2616ln(RBQUAL) (.13) (2.51)	R^2=.021	F=6.31

4. Conclusions: Dollar Values of Willingness to Pay in the Boston SMSA

Willingness to pay for water quality exceeds zero despite the generally poor perception of water quality. The evidence suggests that the net benefits implied by this do not necessarily derive from the direct usage of the water, but may also be based on an option demand character of water quality. Bostonians appear to value conservation.

Willingness to pay to either achieve water quality improvements or avoid water quality degradation increases with better site quality. In other words, the value of improving/maintaining good sites is greater than that for poorer sites. This finding holds once income and distance (setting) effects are removed as well. It suggests there are increasing returns to water quality improvements. Because the costs of water pollution abatement typically display increasing marginal costs, this finding implies that much higher levels of water quality contact than previously thought may be socially efficient.

From the response to the willingness-to-pay questions (WTP2 or WTP3), a dollar value of water quality improvements (or cost of declines) can be estimated from the formula developed in Section 1. Recall these estimates probably overstate the true net benefits. We assume our sample is representative of the Boston SMSA population, and no adjustments are needed to account for variation due to social, economic or other factors. On the average, responding households made 20.75 visits to a recreation site during the period. Valued at the median willingness-to-pay figure (1.259) this implies a value of about 26.11 per household per year for water quality improvements. This equals $17.3 million per year for the 1970 Boston SMSA population. Using the mean figure of $2.065, the per capita figure becomes $42.85 per year, and the SMSA figure rises to 28.4 million per year. Because the data are categorical, confidence bands for these estimates cannot be simply calculated. But the distribution is skewed to the right, so any equal probability confidence intervals would find deviations to the high side more likely. Remember that this value is not necessarily generated by direct recreation usage alone, but also by the conservation value of achieving and maintaining good quality water in the Boston area.

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VII. MULTIPLE SITE DEMAND FUNCTIONS

The formal economic analogue to willingness-to-pay is consumer's surplus measured from an appropriately specified demand function. Our analysis focuses on multiple site demand systems because substitutions between the sites were significant. Table VII-1 shows the response to a direct question on substitutions:

> Let's talk about the beach, lake or river site you visited most, that was ______________, site number _______.
>
> If water quality became much worse (declined to a ranking of 1), what would your response be?
>
> a. still visit the same beach as much
>
> b. visit that site less frequently and some other site more (specify which one below)
>
> c. visit that site less frequently and participate in some other non-water-based recreation more (specify which activity below).
>
> d. participate in outdoor recreation less, no change in other leisure
>
> e. participate in outdoor recreation less and indoor recreation more.

Most (56.9%) respondents would shift to their second most favorite site. Over three-quarters of all respondents would continue to participate in water-based activities at the system of sites under study.

Table VII-1

Substitution Induced by Water Quality Decline

	Response	No.	Percent
a.	still visit the same beach as much	83	20.9
b.	visit that site less frequently and some other site more	226	56.9
c.	visit that site less frequently and participate in some other non-water-based recreation more	53	13.4
d.	participate in outdoor recreation less, no change in other leisure	21	5.3
e.	participate in outdoor recreation less and indoor recreation more	14	3.5

Five sections complete the demand analysis. The first section discusses in a qualitative way demand at the system of sites. Section 2 presents some aggregated regressions which focus more specifically on the determinants of recreation behavior. These sections, combined with the background matter presented in previous chapters, set the stage for the demand modelling of sections 3 and 4. Section 3 employs the abstract site demand functions pioneered in transportation economics to estimate the functional relationships between site characteristics and site demand. However, the specification does not permit recovery of an exact measure of consumers' surplue (net benefit), so Section 4 considers a system of demand equations derived explicitly from a utility model. Unfortunately, estimation of these equations, a complex operation, exceeded the level of the project's resources. This model is left specified but not estimated. The last section presents benefit estimates from the abstract site model, and comments on benefit estimates from the system demand model.

1. A Review of the Data

Table VII-2 shows the number of mentions and visits for each site in our survey. The first column contains the number of households who visited each site at least once during the summer of 1974; the second column gives the total number of visits to the site by these households. The median number of visits to a site, computed from the third column of the table, is 7 visits per household. For reasons to be explained below, the statistical analysis will be focused mainly on sites 1-29; these sites account for almost 80% of the total number of mentions but only 66.6% of the total number of household visits. Thus the excluded sites appear to have a somwhat higher average visitation rate per household. In fact, however, this is misleading because some of the excluded sites are really composites of individual sites. If we adjust for this, the average visitation rates for the included and excluded sites would be fairly similar.

To get some feel for the coverage of the sample Table VII-3 presents a comparison of the site attendances generated by the respondents to our questionnaire and estimates of total attendance at selected sites for which data is available. The data in second column of the table was obtained by multiplying the number of household visits to each site by the average group size and summing this over all respondents. The data in the first column comes from a variety of sources. Attendance figures were generally not available at the head office of the MDC or at other official agencies in Boston, but some data was available from staff at the sites when we visited them. The quality of the data is unknown: some of it comes from a survey conducted in 1969; in other cases the data is based on parking and entrance fee receipts. Taking this data at face value, observe that the households in our sample generated 0.13% of the estimated total attendance at these sites. This may be compared with the ratio between our sample population and the total Boston area population, which

Table VII-2

Individual Site Visits and Mentions

Site	# of Mentions	# of Household Visits	(2)/(1)
1	21	150	7.1
2	45	306	6.8
3	98	681	6.9
4	112	906	8.1
5	9	98	10.9
6	15	68	4.5
7	14	188	13.4
8	30	107	3.6
9	7	22	3.1
10	11	44	4.0
11	9	209	23.2
12	11	121	11.0
13	11	57	5.2
14	4	16	4.0
15	30	382	12.7
16	115	948	8.2
17	51	256	5.0
18	74	306	4.1
19	43	167	3.9
20	23	77	3.3
21	15	80	5.3
22	34	212	6.2
23	14	162	11.6
24	17	216	12.7
25	20	312	15.6
26	47	180	3.8
27	8	26	3.3
28	22	143	6.5
29	2	15	7.5
30	24	294	12.3
31	43	556	12.9
*32	12	102	5.7
33	10	71	7.1
*34	4	8	2.0
35	9	94	10.4
36	4	74	18.5
37	4	96	24.0
*38	27	408	15.1
*39	24	300	12.5
*40	18	119	6.6
41	11	141	12.8
*42	49	937	19.1
*43	6	30	5.0
All Sites	1163	1685	8.3
Mean	2.49	20.74	9.0

NOTE: Column (1) excludes those respondents who mentioned a site for the purpose of rating its characteristics but did not actually visit it.

An Asterisk denotes those "sites" which are actually groups of individual sites; each mention refers to a different individual site and/or different respondent.

Table VII-3

Total Attendance and Attendance from Sample Households At Selected Sites

Site	(1) Estimated Annual Attendance (10^3 visitor days)	(2) Attendance by Sample Households (visitor days)	(3) Percent of Total Attendance Generated by Sample
1	2000	428	0.17
2		957	
3		1998	
4	6400	5124	0.08
5	350	2021	0.58
6	750	289	0.04
7	500	881	0.18
9	2500	92	0.02
10		90	
12		384	
15	750	1628	0.22
16	2700	3370	0.12
18	140	1246	0.89
22	150	918	0.61
23	175	991	0.57
24	750	602	0.08
27	40	84	0.21
28	120	662	0.55
29	105	141	0.13
TOTAL	17,430	21,911	0.13

NOTE: Column (2) is number of visits by household members to sites multiplied by average group size.

Column (3) contains fractions of one percent.

amounts to about 0.06%. The comparison suggests that the households in our sample could be responsible for more recreation visits than the average household in the Boston area. However, this conclusion must be treated with considerable caution, for the total attendance estimates are not reliable. Some of these figures date back to 1969 and others are only guesses of numbers of automobiles, so that they understate present attendance levels. On the other hand, it should be noted that the attendance may have been generated by a population larger than that of the Boston metropolitan area, since they may contain visits by tourists from elsewhere in the state or from out of state.

The next issue to be considered is how many sites each household visits. We pointed out in Chapter III that certain statistical site demand models could be applied only if it were believed that each individual visited one and only one of the alternative sites. It is therefore important to check the validity of this assumption. Table VII-4 shows the distribution of the number of sites visited by respondents. It is clear that the assumption is not valid: two thirds of the sample visited more than one site in the summer of 1974. In fact, that mean number of sites visited was 2.5 sites per household, and the median and modal number was 2 sites. Thus we must rule out those models which presuppose the choice of a single site.

In fact, two types of demand models were estimated. The explanatory variables in one type include income and household structure and the own price and quality variables for the site; in the other type of models, besides these variables, there are also the prices and quantities of the other (n-1) sites. In order to generate the data on subjective site quality ratings necessary for the implementation of the second type of model we included questions in our questionnaire asking respondents to rate the quality of other sites which they knew about but did not visit. Unfortunately, these questions were not very successful and,

Table VII-4

Household Site Visitation Patterns

# of Sites Visited	# of Occurrences
0	56
1	106
2	114
3	69
4	54
5	21
6	17
7	10
8	8
9	3
10	2
11	1

for one reason or another, most respondents did not answer them. Thus, while we have 1312 site cards, each representing the metnion of one site by one respondent, only 148 cards represent the mention of sites which the respondent did not visit but where he was willing to rate site quality. To all intents and purposes, then, we do not have subjective ratings of the sites which respondent did not visit. Since most respondents visited only 2 or 3 sites, this rules out the majority of the sites where we wish to model demand. Accordingly, if we wish to include a full set of (n-1) other site variables in each demand equation, we have to use the objective measure of water quality obtained from our water samples from 29 sites. This is why we are forced to exclude sites 30-43 from most of the statistical anlaysis.

The same problem arises with the price variable. However, there are some additional considerations. The questionnnaire asks how much it costs respondents to gain access to a site in parking or entrance fees. It also asks how much respondents spend once they are at the site. As Table VII-5 shows, most persons said that they incurred no expenditures for access--about 73% of the mentions indicate a zero price--and about one third of the respondents said they had no on-site expenditures. We cannot tell how accurate these responses are: since the interviews were administered three months after the end of the summer recreation season, it is possible that the respondents have underestimated their true expenditures. In view of these difficulties, we have decided throughout this chapter to replace price with distance, which is easily computed for all sites. This is a quite common practice in recreation studies and is justified if travel and access costs are proportional to distance. That this might be so is suggested by the following regression of access costs, as reported by respondents, on distance (in miles):

$$\underset{(1.06)}{\text{Price} = 0.0949} + \underset{(4.73)}{0.04086}\ \text{Distance} \qquad R^2 = .012 \quad F = 22.35 \quad \text{(1214 observations)}$$

Table VII-5

Occurrences of Zero Expenditures for Site Visits

Site	# of Mentions	# of Mentions with Zero Expenditures for Access	# of Mentions with Zero Expenditures On-site
1	21	20	11
2	45	35	32
3	98	56	45
4	112	94	54
5	9	8	6
6	15	13	12
7	14	12	10
8	30	29	20
9	7	7	5
10	11	11	8
11	9	9	3
12	11	10	4
13	11	7	7
14	4	0	1
15	30	30	28
16	115	81	51
17	51	27	29
18	74	30	41
19	43	29	30
20	23	14	15
21	15	10	9
22	34	34	25
23	14	13	9
24	17	16	15
25	20	20	18
26	48	45	39
27	8	5	7
28	22	9	18
29	2	1	2
30	24	24	22
31	43	42	41
32	18	9	8
33	10	3	6
34	4	4	2
35	9	9	8
36	4	3	3
37	4	4	4
38	27	24	20
39	24	17	23
40	18	11	5
41	11	11	8
42	49		
43	6	5	1
All Sites	1164	241	408

NOTE: This table excludes those respondents who mentioned a site for the purpose of rating its characteristics but did not actually visit it.

2. Some Determinants of Recreation Activity

Although the following sections present demand functions for individual sites, it is interesting to consider how the total number of sites visited or the total number of visits to all sites per household is affected by various socio-economic and demographic factors. Some regressions with thse dependent variables are shown in Table VII-6. The first equations deal with household income and structure. KIDS is the number of persons aged 17 and under in the respondents' household; PEOPLE is the total number of persons of all ages in the household. We might expect that the number of children in the household would have a stronger effect on the scope of the household's beach recreation activity than the total size of the household. The opposite appears to be the case:* in no case was the slope coefficient significantly different from zero for KIDS. Also, it appears that the household income has no influence on the total number of visits to all sites by household (although it does affect the total number of sites visited--richer families are likely to visit more sites than poor families). However, the relationship is fairly weak and is complicated by the collinearity between household income and size.**

The next two regressions deal with racial differences in recreation activity. IRISH is dummy variable taking the value 1 if the respondent described himself as having an Irish background. ITALIAN is a dummy variable for respondents with an Italian background and OTHER CAUCASIAN is a dummy variable for other Caucasian backgrounds. Thus the slope coefficients represent differential effects relative to respondents from minority groups--American Indian, Asian-American, Black and Spanish Surname. In the regressions of both numbers of visits to all sites and number of sites visited

---

*Similar results were obtained when we used a dummy variable taking the value 1 if there were children and 0 if there were none, in place of the continuous variable KIDS.

**In these regressions we have replaced missing household income values with the sample mean, $14,137. This is the so-called zero-order regression method--see Afifi and Elashoff [1]; in the present context it produces unbiased but inefficient estimates.

Table VII-6

Total Site Visitation as a Function of Selected Socioeconomic Characteristics

(462 observations)

# VISITS = 8.309 + 0.7117ln(INC) + 1.4317 PEOPLE (.37) (.30) (2.08)	R^2=.01	F=2.41
# VISITS = 15.012 - 1373.79/INC + 1.4628 PEOPLE (3.86) (.08) (2.13)	R^2=.01	F=2.37
# SITES = 0.116 + 0.2428ln(INC) + 0.1736 KIDS (.08) (1.58) (.89)	R^2=.008	F=1.74
# SITES = 2.611 - 2099.74/INC + 0.1783 KIDS (13.26) (1.82) (.92)	R^2=.009	F=2.14
# SITES = 0.39 + 0.1746ln(INC) + 0.1148 PEOPLE (.27) (1.12) (2.55)	R^2=.02	F=4.59
# SITES = 2.203 - 1654.43/INC + 0.1142 PEOPLE (8.67) (1.43) (2.55)	R^2=.022	F=4.98
INC = 11266.4 + 732.145 PEOPLE (13.5) (4.09)	R^2=.035	F=16.75
# VISITS = 13.94 + 16.02 IRISH + 5.2 ITALIAN + 5.4 OTHER CAUCASIAN (3.20) (3.01) (0.95) (1.13)	R^2=.026	F=4.07
# SITES = 1.98 + 0.95 IRISH + 0.77 ITALIAN + 0.38 OTHER CAUCASIAN (6.89) (2.7) (2.13) (1.22)	R^2=.022	F=3.38
# VISITS = 18.30 + 3.213 AUTO OWNERSHIP (5.33) (0.85)	R^2=.002	F=.73
# SITES = 2.14 + 0.448 AUTO OWNERSHIP (9.51) (1.81)	R^2=.007	F=3.29
# VISITS = 19.46 + 0.527 DAYS WORKED PER WEEK (4.78) (0.39)	R^2=.000	F=.16
# SITES = 1.973 + 0.188 DAYS WORKED PER WEEK (7.4) (2.15)	R^2=.01	F=4.6

the hypothesis that the slope coefficients are all zero--if there is no difference in the recreation behavior of minority and other groups--is rejected at the .05 level. However, in the first regression, it is clear that only the Irish have a significantly different recreation behavior--on average they make 16 more visits per household--while Italian and other Caucasian respondents have the same behavior as minority group respondents. In the case of the number of sites visited, both Irish and Italian, but not other Caucasians, have a significantly different behavior from minority groups; moreover, the hypothesis that Irish and Italian respondents have the <u>same</u> behavior cannot be rejected at the .05 level.

The remaining regressions show that automobile ownership has some effect on the number of sites visited, but not on the total of visits to all sites; and also that the length of the working week has a similar effect. However, the sign of the relationship is the opposite of what we might expect--it appears that longer working weeks lead to a larger number of sites being visited. In some regressions not reported here, we found no relationship between the length of paid vacation and the total number of visits to all sites or the total number of sites visited. This is not surprising since our data pertains to day trips and we might expect vacation length to influence more extended trips but not day trips.

3. Abstract Site Demand Functions

The demand functions presented in this section differ from the demand functions to be discussed in the next section in two ways. Firstly, the demand functions presented in this section contain only own price and quality variables. Secondly, they are not derived from an explicity utility function.* On the other hand, the demand functions in this section differ from those estimated by Clawson and Knetch [5], and those who have copied their methodology in that instead of estimating separate demand functions for each site or for groups of sites and included site quality explicity as an explanatory variable. The demand functions thus resemble the "abstract mode" demand functions pioneered in transportation economics by Quandt and Baumol [9]. The functions which we estimate have the following form

$$V_{it} = f[d_{it}, Z_i, C_{it}, Y_t] \qquad \ldots (1)$$

where V_{it} is the number of visits to a site i by an individual t, d_{it} is the distance traveled (a proxy for price) for individual t in visiting site i, Z_i is a vector of "objective" characteristics of site i, C_{it} is a vector of characteristics of site i as perceived by individual t, and y_t is a fector of characteristics pertaining to individual t, such as household income and composition.

At this point we must deal with the question of zero visitation rates. As Table VII-4 indicates, nobody in our sample visits all of the possible sites and indeed, most people visit very few of them. We re-

*In Section 3 of Chapter 3 we suggested a specific utility function which would lead to demand functions containing only own price and quality variables--see equation (13) of Chapter 3. However, as we pointed out, these particular demand functions require a form of constrained estimation which would be very burdensome computationally, and we have not attempted to estimate them.

marked in Chapter III that the problem of zero visitation rates can be incorporated into stochastic choice system demand models, but it would be prohibitively expensive to apply such a model when there are so many alternative sites. It is relatively easier to deal with this phenomenon in the context of the ad-hoc demand functions represented by (1). Since there are 4627 respondents in our sample and 29 sites (at least), (V_{it}) would be a vector with 13,543 (= 467 x 29) rows. 912 elements of (V_{it}) would be non-zero--this is the number of mentions corresponding to sites 1-29, as listed in Table VII-1--and the remainder would be zero. The obvious estimation method would be Tobit analysis.* Unfortunately, however, the data sets involved are too large to be handled by the conventional Tobit programs. The alternative is a two-step procedure suggested by Goldberger [6], in which the analysis is broken down into two issues.** The first issue is what determines whether a given individual visits a given site at all. We can think of the dependent variable, V_{it}, as being a dummy variable which takes the value 1 if individual t makes at least one visit to site i, and the value zero otherwise. Thus (V_{it}) is a 13543 x 1 vector of 1's and 0's. The second issue is: given that an individual visits a site, what determines how many times he visits it? In this case, the analysis is restricted to the subject of cases where visits are actually made, and the dependent variable, V_{it}, is a 912 x 1 vector containing the (non-zero) numbers of visits by each household to each site.

The two-stage procedure does not necessarily produce the same coefficient estimates as the theoretically preferable Tobit analysis, but is is the best alternative available. Moreover, as Goldberger [6] points out, it is somewhat more flexible than the Tobit procedure because it allows us to specify different.sets of regressors in the two stages of the estimation. Thus the factors which determine the probability of an individual's making any visit to a site need not be the same as those which determine how many

*See, e.g., Goldberger [6].

**Goldberger [6].

visits he makes to those sites which he does visit. We intend to exploit this opportunity; indeed it is necessary for us to do so because, as noted in Section 1, subjective site ratings are generally available only for those sites which respondents actually visited. Thus these variables can be included in the second, but not the first stage regression. Moreover, in our opinion, certain socio-economic variables such as household income and size are not likely to influence whether an individual visits a random site, although they are likely to influence how many visits an individual makes to a site which he does visit.* Therefore, we propose to exclude these two variables from the first stage regressions.

The first-stage regressions, although computationally more convenient than Tobit analysis, are by no means problem free. The dependent variable in those regressions is a dummy variable and OLS is not a natural estimation method in these circumstances. The normal practice is to use maximum likelihood estimates based on some specification of the random process which generates the 1's and 0's, the most common specifications being the Probit and the Logit models. The two models are quite similar but, since the latter is more convenient for reasons to be explained below, we adopt it here. The idea behind Logit (and Probit) analysis is similar to the idea behind the discrete dependent variable model presented in Chapter III. We assume that there is an underlying unobserved continuous variable W given by

$$W = \alpha + \Sigma x_j \beta_j + \tilde{u} \qquad \ldots (2)$$

and the observed dichotomous variable V is generated from W by the rule

*This statement may not be strictly true in the light of the results reported in Section 2. An alternative statement, which may be more acceptable, is that the influence of household income and size on the probability that an arbitrary individual visits an arbitrary site is less interesting than the influence of these variables on the number of visits made by an individual to those sites which he does visit.

$$V = \begin{cases} 1 & \text{if } W>0 \\ 0 & \text{if } W<0 \end{cases} \qquad \ldots (3)$$

Thus if H (•) is the cumulative distribution function of the random variable $\tilde{u}$, we have:

$$P = \text{Prob}[V-1] - H[-\alpha - \Sigma x_j \beta_j]$$
$$(1-P) = \text{Prob}[V-0] = 1-H[-\alpha - \Sigma x_j \beta_j]$$

If $\tilde{u}$ is assumed to be normally distributed, we have the Probit Model; if $\tilde{u}$ is assumed to follow the logistic distrubtion, we have the Logit model. In the latter case we observe that

$$\log \frac{P}{1-P} = \alpha + \Sigma x_j \beta_j$$

and

$$P = \frac{1}{1 + e^{-\alpha - \Sigma x_j \beta_j}}$$

For either model the likelihood function is

$$\mathcal{L} = \prod_{V_{it}=1} H[-\alpha-\Sigma x_j \beta_j] \prod_{V_{it}=0} (1-H[-\alpha-\Sigma x_j \beta_j]) \quad \ldots (4)$$

It would be possible to obtain maximum likelihood estimates of the coefficients ($\Sigma x_j \beta_j$) on the basis of (4) but, given the size of our data set, this would be very expensive. Instead we shall avail ourselves of a much simpler computational procedure suggested recently by Haggerstrom [7], on the basis of work by Halperin, Blackwolder and Verter [8]. The latter authors show that maximum likelihood estimates of the parameters of the Logit model in practice are very close to the coefficient estimates obtained by discriminant analysis. Haggerstrom points out that discriminant analysis coefficients can be obtained from a relatively simple transformation of ordinary least squares regression coefficients using a dummy-dependent variable. Thus, while OLS by itself is not an appropriate technique for handling dummy dependent variables, the OLS coefficient estimates when suitably transformed provide a good approximation to the maximum likelihood estimates of the Logit coefficients, and the OLS t and F statistics may reasonably be used to test hypotheses about the Logit coefficients. It should be noted that, although the predicted values of the dependent variable obtained using OLS are not constrained to lie between 0 and 1, the predicted values of the dependent variable obtained from the transformed OLS coefficients do satisfy this constraint. Haggerstrom shows that, if (α, β_j) are the OLS coefficient estimates and $(\hat{\alpha}, \hat{\beta}_j)$ the discriminant analysis coefficient estimates the required transformation is:

$$\hat{\beta}_j = C\beta_j$$

$$\hat{\alpha} = \log (P_1/P_2) + C[\alpha - \tfrac{1}{2}] + \tfrac{n}{2}[n_1^{-1} - n_2^{-1}]$$

where C = n/SSR, SSR being the sum of squared residuals from the OLS regression n_1 is the number of cases in which the dependent variable takes the value 1 (i.e. 912), n_2=n-n=12,486, $P_1=n_1/n$, and $P_2=n_2/n$.

For the reasons mentioned above, we decided that the most important regressor variables for the first stage analysis were the distance of individual t from the site i and some measures of water quality at site i. On the basis of the regression analysis of willingness to pay and the accuracy of subjective perception of water quality parameters reported elsewhere, we decided to confine our analysis to three parameters--color, coliform bacteria counts and phosphorous content. When we came to implement the OLS regression of a dummy variable for site visitation we found that, even using OLS, the data set exceeded the capacity of the programs available to us, so we restricted ourselves to no more than two regressions and truncated the data set at 11,000 observations. The results of these regressions are shown in Table VII-7. The regression coefficients have the signs which we would expect and are significantly different from zero: the greater the distance and the more polluted a site (in terms of color, coliform bacteria or phosphorus) the lower the

Table VII-7

Probability of Site Visitation -- Logit Model

Variable	OLS Estimate	Discriminant Estimate	OLS Estimate	Discriminant Estimate	OLS Estimate	Discriminant Estimate
CONSTANT	0.1682 (25.6)	-1.245	0.1094 (22.73)	-2.0437	0.1944 (27.79)	-0.392
DISTANCE	-0.00433 (11.5)	-0.06543	-0.003 (8.18)	-0.04465	-0.00533 (13.73)	-0.08129
PHOSPHORUS	-0.7332 (13.95)	-11.0799				
COLI			-0.00000315 (4.97)	-0.0000469		
COLOR					-0.00803 (17.26)	-0.1232
R^2	.022		.007		.031	
F	120.42		39.12		176.38	
SSR	727.91		739.12		721.25	
n/SSR		15.11		14.88		15.25

$n = 11{,}000;\ n_1 = 803;\ n_2 = 10{,}197$

$\log(P_1/P_2) + \frac{n}{2}\left[\frac{1}{n_1} - \frac{1}{n_2}\right] = 3.768$

probability that a respondent visits it. The impact of objective water quality conditions on the probability that a site is visited at least once is unambiguously established by these results.

However, when we come to the second stage regressions--the OLS regression of the number of visits by members of a respondent's household to each site which it visits--we reach a rather different conclusion. Tables VII-8 and VII-9* presents the results of several regressions of this variable on various sets of regressors including alternatively subjective water quality ratings and objective measures of water quality. The other variables are distance from site (DIST), household income** and size (INC, PEOPLE) and a dummy variable, ACCESS, which takes the value 1 if the site is accessible by public transportation and the value 0 otherwise.*** Several results stand out in these regressions. DIST always has a significant negative coefficient and although the coefficient of INC is unstable in sign and frequently insignificant--at least partly because of the colinearity with PEOPLE--in the preferred equations it is positive and fairly significant. As we might expect, household size and accessibility to public transport always have a positive effect on the number of visits to a site although these slope coefficients are not always significant.

The most important findings concern the relative performance of subjective and objective measures of water quality as explanatory variables. Subjective water quality rating always has a significant positive coefficient--respondents make more visits to a site which they consider to be of higher quality. This is not a surprising conclusion, although

*There are 819 rather than 912 observations because 93 site cards contain no water or beach quality ratings.

** As with the regressions presented in section 2, we have replaced missing income values with the mean income of $14,317.

*** In Tables VII-7 and VII-8 an asterisk marks the preferred equation. The choice between functional forms is based on the Box & Cox [3] maximum likelihood criterion.

Table VII-8

Abstract Site Demand Functions with Subjective Quality Ratings

(819 observations)

$$\text{VISITS} = \underset{(2.76)}{4.226} + \underset{(1.53)}{7903.46/\text{INC}} + \underset{(2.68)}{0.8649}\ \text{RWQUAL} - \underset{(5.73)}{0.3775}\ \text{DIST} + \underset{(2.63)}{2.2461}\ \text{ACCESS} - \underset{(2.13)}{0.3804}\ \text{PEOPLE} \qquad R^2=.076 \quad F=13.32$$

$$\text{VISITS} = \underset{(3.79)}{5.431} - \underset{(.14)}{.00000675}\ \text{INC} + \underset{(2.65)}{0.8567}\ \text{RWQUAL} - \underset{(5.89)}{0.3889}\ \text{DIST} + \underset{(2.61)}{2.2323}\ \text{ACCESS} + \underset{(1.86)}{0.3346}\ \text{PEOPLE} \qquad R^2=.073 \quad F=12.82$$

$$\text{VISITS} = \underset{(1.84)}{11.441} - \underset{(1.00)}{0.67 \ln(\text{INC})} + \underset{(2.66)}{0.8567}\ \text{RWQUAL} - \underset{(5.77)}{0.3811}\ \text{DIST} + \underset{(5.76)}{2.2376}\ \text{ACCESS} + \underset{(2.60)}{0.3665}\ \text{PEOPLE} \qquad R^2=.074 \quad F=13.033$$

$$\ln(\text{VISITS}) = \underset{(10.39)}{1.363} + \underset{(1.16)}{512.653/\text{INC}} + \underset{(2.7)}{0.0745}\ \text{RWQUAL} - \underset{(8.23)}{0.0464}\ \text{DIST} + \underset{(1.2)}{0.088}\ \text{ACCESS} + \underset{(1.12)}{0.0172}\ \text{PEOPLE} \qquad R^2=.103 \quad F=18.573$$

$$\ln(\text{VISITS}) = \underset{(9.93)}{1.375} + \underset{(1.16)}{512.887/\text{INC}} + \underset{(2.61)}{0.0776}\ \text{RWQUAL} - \underset{(.27)}{0.0077}\ \text{RBQUAL} - \underset{(8.22)}{0.0463}\ \text{DIST} + \underset{(1.20)}{0.0875}\ \text{ACCESS} + \underset{(1.14)}{0.0175}\ \text{PEOPLE} \qquad R^2=.103 \quad F=15.473$$

$$*\ln(\text{VISITS}) = \underset{(11.13)}{13.607} + \underset{(1.78)}{0.0000072}\ \text{INC} + \underset{(2.76)}{0.0759}\ \text{RWQUAL} - \underset{(8.62)}{0.0485}\ \text{DIST} + \underset{(1.18)}{0.0861}\ \text{ACCESS} + \underset{(5.56)}{0.00856}\ \text{PEOPLE} \qquad R^2=.105 \quad F=18.98$$

$$\ln(\text{VISITS}) = \underset{(2.65)}{1.409} + \underset{(.05)}{0.003041 \ln(\text{INC})} + \underset{(2.69)}{0.0741}\ \text{RWQUAL} - \underset{(8.36)}{0.0472}\ \text{DIST} + \underset{(1.19)}{0.087}\ \text{ACCESS} + \underset{(0.90)}{0.0138}\ \text{PEOPLE} \qquad R^2=.101 \quad F=18.275$$

Table VII-9

Abstract Site Demand Functions with Objective Quality Variables for 29 Sites

$$\text{VISITS} = \underset{(3.92)}{5.83} + \underset{(1.48)}{7693.71/\text{INC}} + \underset{(0.26)}{0.0000344\ \text{COLI}} + \underset{(0.57)}{0.0526\ \text{COLOR}} - \underset{(4.67)}{0.3025\ \text{DIST}} + \underset{(2.21)}{1.9361\ \text{ACCESS}} + \underset{(2.38)}{0.426\ \text{PEOPLE}} \qquad R^2=.068 \quad F=9.901$$

$$\text{VISITS} = \underset{(3.69)}{5.525} + \underset{(1.37)}{7110.52/\text{INC}} - \underset{(0.44)}{0.000054\ \text{COLI}} + \underset{(0.4)}{0.044\ \text{COLOR}} + \underset{(1.68)}{24.217\ \text{PHOSPHORUS}} - \underset{(4.52)}{0.2935\ \text{DIST}} + \underset{(2.05)}{1.8\ \text{ACCESS}} + \underset{(2.14)}{0.387\ \text{PEOPLE}} \qquad R^2=.071 \quad F=8.907$$

$$\text{VISITS} = \underset{(5.07)}{7.023} - \underset{(0.23)}{0.00001105\ \text{INC}} + \underset{(0.26)}{0.0000352\ \text{COLI}} + \underset{(0.57)}{0.0531\ \text{COLOR}} - \underset{(4.84)}{0.3133\ \text{DIST}} + \underset{(2.20)}{1.9239\ \text{ACCESS}} + \underset{(2.14)}{0.3843\ \text{PEOPLE}} \qquad R^2=.066 \quad F=9.52$$

$$\ln(\text{VISITS}) = \underset{(12.12)}{1.54} + \underset{(1.12)}{495.99/\text{INC}} + \underset{(1.29)}{0.0000146\ \text{COLI}} - \underset{(0.4)}{0.00318\ \text{COLOR}} - \underset{(7.36)}{0.0408\ \text{DIST}} + \underset{(0.69)}{0.0514\ \text{ACCESS}} + \underset{(1.45)}{0.0222\ \text{PEOPLE}} \qquad R^2=0.96 \quad F=14.424$$

$$\ln(\text{VISITS}) = \underset{(12.02)}{1.54} + \underset{(1.11)}{494.95/\text{INC}} + \underset{(1.17)}{0.0000144\ \text{COLI}} - \underset{(0.36)}{0.00335\ \text{COLOR}} + \underset{(0.03)}{0.043\ \text{PHOSPHORUS}} - \underset{(7.33)}{0.0407\ \text{DIST}} + \underset{(0.68)}{0.0152\ \text{ACCESS}} + \underset{(1.43)}{0.0221\ \text{PEOPLE}} \qquad R^2=.096 \quad F=12.35$$

$$*\ln(\text{VISITS}) = \underset{(13.05)}{1.541} + \underset{(1.65)}{0.00000672\ \text{INC}} + \underset{(1.27)}{0.0000143\ \text{COLI}} - \underset{(0.35)}{0.00279\ \text{COLOR}} + \underset{(7.72)}{0.426\ \text{DIST}} + \underset{(0.66)}{0.0494\ \text{ACCESS}} + \underset{(0.91)}{0.014\ \text{PEOPLE}} \qquad R^2=.098 \quad F=14.7$$

$$\ln(\text{VISITS}) = \underset{(2.98)}{1.59} + \underset{(0.04)}{0.0021\ \ln(\text{INC})} + \underset{(1.3)}{0.0000146\ \text{COLI}} - \underset{(0.4)}{0.0031\ \text{COLOR}} - \underset{(7.5)}{0.0416\ \text{DIST}} + \underset{(0.68)}{0.0505\ \text{ACCESS}} + \underset{(1.22)}{0.0188\ \text{PEOPLE}} \qquad R^2=.095 \quad F=14.2$$

the direction of causation is ambiguous. It might be best to regard site ratings as jointly endogenous variables together with site visitation rates, the true exogenous variables being the objective measures of site quality. However, there is very little relationship between objective measures of site quality and the frequency with which a site is visited. The coefficients of COLOR, COLI BACT and PHOS are usually insignificant and frequently of the "wrong" sign. The data provides little evidence that objectively better sites are visited more frequently, other things being equal.

Thus, we may conclude that if a site has a better water quality there is a higher probability that a household taken at random will visit it at least once but, given that the household does visit the site, there is little reason to believe that the site is visited more frequently than other sites of lower water quality. On the other hand, households make more visits to sites which they believe to be of a higher quality--or perhaps the converse is true: households believe that the sites which they visit often are better than those which they visit rarely. This discrepancy is similar to that observed in the analysis of willingness-to-pay; households were willing to pay more for sites which they believed to be of a higher quality, but not necessarily for sites wihich objectively had a higher quality. It is consistent with our finding in Chapter 5 that subjective site rating match up with objective site conditions only imperfectly.

4. System Demand Functions

Chapter 3 suggested the following model for deriving site demand functions based on p characteristics Z_{ij}:

$$U = \Sigma b_i \log(V_j - c_i) \qquad \ldots \text{(1a)}$$

$$c_i = W_{io} + \sum_{k=1}^{p} W_k Z_{ik} \qquad \ldots \text{(1b)}$$

The demand functions obtained from this utility model are:

$$V_{it} = c_i + \frac{b_i}{\sum_{j=1}^{n} b_j} \frac{1}{P_{it}} [Y_t - \sum_{j=1}^{n} P_{jt} c_j] \quad i=1\ldots n \ \ldots \text{(2)}$$

where V_{it} is the number of visits to site i by individual t. The standard practice in consumer demand theory is to normalize the b_i's so that $\Sigma b_i = 1$, in which case (2) can also be written in expenditure form as

$$P_{it} \cdot V_{it} = P_{it} c_i + b_i [Y_t - \Sigma P_{jt} c_j] \qquad \ldots \text{(3)}$$

This function is nonlinear in the parameters b_i and c_i (or, equivalently, in the parameters b_i and W_{io}, W_k). Two alternative estimation procedures are available: a maximum likelihood estimation procedure due to Parks [10] and less sophisticated iterative two-part procedure due to Stone [12]. Because of its computational simplicity, we shall follow Stone's procedure here. This procedure is based on the fact that, for a given set of values of the parameters b_i, equations (2) and (3) are linear functions of c_i (or, equivalently, of W_{io} and W_k), while for a given set of values of the parameter c_i, these equations are linear functions of b_i. Stone's method is to iterate between OLS estimates of b_i, for given values of c_i, and OLS estimates of c_i, for given values of b_i.

At this point we have to face the fact, hitherto neglected, that we are actually dealing with a subset of commodities--namely, expenditures on recreation sites--rather than with the whole set of consumption items. This raises the question of whether the theory developed for the latter situation can be applied here. The answer is that the general theory does carry over to the case of a subset of commodities if the consumer's utility function is assumed to be appropriately separable. There are various concepts of separability which we might invole; without going into detail, we may state that an underlying idea of these concepts is that the marginal rate of substitution between any pair of recreation sites should be independent of the consumer's level of consumption of any other commodity besides recreation sites.* This is a strong requirement, but not an entirely unreasonable one. If it is accepted, and if the relevant portion of the consumer's utility function dealing with the utility from beach recreation is given by (1), then the site demand functions are indeed given by (2) or (3), with one change. Site depand depends on the prices of the n sites and on the total expenditure on beach recreation, rather than income. Thus, the variable, Y, in (2) or (3) must be taken as standing for total expenditure on water-oriented recreation. This variable is then endogenous to the consumer's choice process, and is, therefore, a function of the prices of both recreation sites and (in general) all the other commodities as well as income. Instead of trying to model the determinants of recreation expenditure explicitly, we shall employ the assumption commonly used in Engle curve analysis

*See, for example, Pollak [11].

that there is relatively little variation in the prices of non-recreation goods faced by our sample households; hence, we may postulate some simple relationship between expenditure on beach recreation (Y) and income, such as

$$Y = d_o + d_i INC \qquad \ldots (4a)$$

or

$$Y = d_o + d_1 \ln(INC) \qquad \ldots (4b)$$

If we substitute (4a) or (4b) into (2) or (3) we have a fully specified system of demand equations for recreation sites, under the separability assumption.

There are still some complications due to the fact that, for the reasons outlined in Section 1, we do not have good price data. Because of this deficiency, we have chosen to use distance as a proxy for price and, as we observed in the previous section, this seems to be a good substitute. However, in the context of system demand models, this substitution causes some problems because it means that the "adding-up condition" no longer applies--i.e., it is no longer true that for each individual, the sum of the left-hand side variables in Equation (3) over all sites is exactly equal to Y, the total expenditure on water-oriented recreation. The adding-up condition in practice has an important role in the estimation of (2) or (3) both with the maximum likelihood procedure and with Stone's method. In the latter case it helps to ensure that $\Sigma b_i=1$ without the need for constrained estimation techniques. Without this assumption, therefore, we must either use constrained OLS estimation, which is computationally difficult or simplify the model further. We have chosen the latter alternative. Specifically, we have assumed that

$$b_i=b \qquad i=1\ldots n \qquad \ldots (5)$$

and, without any loss of generality, we have taken b=1. Accordingly, the term $(b_i/\Sigma b_j)$ in (2) is replaced by (1/n), n being the number of sites. Since we have in effect suppressed b_i as a parameter, the only parameters to be estimated are the c_i's (i.e., W_{io}, W_k); as we noted above, with the values of b_i known, equations (2) or (3) are linear in the latter variables and a single-stage OLS estimation may be applied. We have, thus, removed the need for iterating on the coefficient estimates, thus greatly reducing the computational difficulty.

The model which we propose to estimate is given by (2), (1b), (4) and (5). We have chosen to use as site characteristics COLOR and COLIFORM; thus, there are 33 coefficients to be estimated: 29 W_{io}'s--one for each site; W_1, the coefficient of COLOR; W_2, the coefficient of COLI; and the parameters d_o and d_1 in (4). We have 912 observations from which to estimate these coefficients, corresponding to the site cards with non-zero visits. Assuming that we share the specification (4a), the actual estimating equations are:

$$P_iV_i = W_{io}P_i\left(\frac{n-1}{n}\right) - \sum_{j\neq i} W_{jo}\frac{P_j}{n} + W_1\left\{Z_{1i}P_i\left(\frac{n-1}{n}\right) + \sum_{j\neq i} Z_{1j}P_{j/n}\right\}$$

$$+ W_2\left\{Z_{2i}P_i\left(\frac{n-1}{n}\right) + \sum_{j\neq i} Z_{2i}P_{j/n}\right\}$$

$$+ \frac{d_o}{n} + \frac{d_1}{n}\text{INC} \qquad i=1\ldots n \qquad \ldots (6)$$

Unfortunately, despite several attempts to model (6), we were unable to do so. The reason was that the data were highly collinear leading to a nearly singular cross-product matrix which could not be inverted. One possible solution may be to group neighboring sites of similar quality so that there is a smaller set of sites differing more in their locations. This would cause the matrix of price (distance) variables to be less collinear and simultaneously reduce the number of parameters to be estimated. Also, it is possible that maximum likelihood estimation of a less specialized version of the model might prove to be more successful. There is ample scope for further research on the specification and estimation of the model, but this was beyond the scope of this project.

5. Benefit Calculation

The only rigorous method to obtain empirical measures of willingness-to-pay for changes in recreation site quality is to estimate a set of demand functions which can be shown to derive from a specific utility function and, using the coefficient estimates, to calculate the resulting change in the area under the compensated function. If the utility function is that given by (1), the corresponding formula for the consumer's surplus associated with a change in site quality is given by Formula (1) in Chapter 3, with the c_i terms replaced by equations (1b) above. Since we are not presently able to estimate this demand model, we are unable to apply this methodology to calculate the benefits of changes in water quality.

We are forced, instead, to rely on the abstract site demand functions described in Section 3. Since these demand functions are not derivable from an explicit utility function, there is no basis for calculating measures of consumer surplus. All that we can do with these demand functions is to predict the impact of water quality changes in site visitation. The only solution is to use some ad hoc metric such as the Principals and Standards estimate that one visitor day is "worth" $.75-$2.50; alternatively, we could value visits at the average willingness-to-pay plus transportation costs as expressed by the respondents to our questionnaire. As an illustration of this procedure, suppose that the coliform bacteria count at a site declines from the average (2000) to the minimum across the samples, 100. Assuming that an individual lives five miles from the site; using the coefficients in the fourth column of Table VII-7, we calculate that the probability that the individual will visit the site changes from:

$$P = \frac{1}{1+e^{2.364}} = 0.086 \quad (COLI=2000)$$

or

$$P = \frac{1}{1+e^{2.2716}} = 0.094 \quad (COLI = 100)$$

If we assume that the individual makes eight visits to a chosen site, and this number is not affected by the change in water quality, the expected visitation of the site changes from 0.69 visits (=0.086x8) to 0.75 visits (=0.094x8). Valuing each visit at $2.50 per person and assuming that there are four persons in the group, the dollar value of the change in water quality for this household is $.64 (=$2.50 x 0.064 x 4). This would equal something less than $400,000 for the whole SMSA, integrating over distance, or $410,000 if the site was five miles from the bulk of the population. This is no doubt a substantial underestimate of the total benefit of the hypothetical coliform reduction since, as Chapter II explains, consumer's surplus has been ignored. The point of this example is principally to illustrate how the abstract site model can be used.

6. Conclusions

This chapter provides interesting additional evidence for some of the points argued elsewhere in the report. First, persons with large families or families with higher incomes tended to visit our sample beaches more frequently than other families. Family ethnic background also appears to influence recreation behavior.

Second, substitution between sites is a significant aspect of recreation behavior in the Boston sample of households and sites. Most respondents visited two or more sites during the summer. Under direct questioning, most cited inter-site substitution as their most likely response to a change in water quality at their favorite beach. Anywhere proximal sites are close substitutes, perhaps most urban areas, inter-site substitution is likely to be an important phenomenon. Thus, single site demand models are not altogether appropriate for either demand forecasting or benefit estimation. We specified a system demand model to account explicitly for this behavior, but were not able to complete its estimation with the resources available to us. This is a fruitful area for further research.

Finally, poor water quality at a site appears to reduce the probability that a randomly selected household will visit the site at all, but does not influence the number of visits to the site given that it is visited at least once. Hence, water quality changes impact recreation behavior principally through inter-site substitutions; this reinforces the need for systems demand models. On the other hand, higher perceived water quality is significantly associated with more visits, but the direction of causation is by no means evident. Again we must conclude that while subjective ratings of water quality match only poorly objective measures, Bostonians seem to value maintaining and improving the area's waters for recreational uses.

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0. CONCLUSIONS

Where did this research take us? The conclusions of the study, presented in each of the chapters below, can be summarized in three parts. First, we explore a number of methodological issues related to recreation demand analysis and the benefits of water quality enhancement. Of particular importance is our theoretical work incorporating substitution between sites in formal demand models and using these models to derive benefit estimates. Hopefully, our work in this area will help other researchers as they try to clarify some of the issues treated in this study, and the broader questions of water quality management.

Second, we use these models to analyze day recreation trips in the Boston SMSA, with particular emphasis on how changes in water quality would influence recreation behavior. These empirical results are of interest to national and regional water quality planning and management, and may also be useful to recreation planners.

Finally, both the methodological and empirical findings of this research suggest several areas where additional research is critical for resolving the issues of this report.

1. Empirical Findings

Perceived Water Quality Does Not Seem to be Related to Actual Water Quality. Bacteria counts, nutrients and so on are not perceived by human senses. Turbidity and color are perceived moderately well by recreationists, but with only a low degree of reliability. Reputations of beaches as being good or bad may be a much more important determinant of water quality perception than the actual quality of the water itself. This conclusion tends to undermine any causal links between recreation behavior and water quality.

Recreation Behavior Is Not Strongly Linked to Objective Measures of Water Quality. No evidence was found to reject this null hypothesis. On the contrary, under direct questioning, water quality appears to follow behind proximity, beach cleanliness, setting and beach facilities in importance to site choice or attendance. These findings are confirmed in the multiple site demand analysis. Some evidence suggests that good water quality is important in determining which sites are visited, but not the number of visits to the site. In light of this finding, the principal benefit, in terms of recreational usage, of water quality improvements in urban areas such as the Boston SMSA would be to reopen beaches which are proximal to large population concentrations.

Despite the Insensitivity of Recreation Demand to Water Quality, Respondents in the Boston SMSA were Willing to Pay from Between $20 to $26 Per Family Per Year for Improved Water Quality. The willingness-to-pay persists across income groups, occupational levels, and amount of education. Water quality appears to be a merit good of significant value. Perhaps, then, attempts to quantify benefits on the basis of consumption are misguided. Water quality, like democracy or national defense, are "goods" desired for their own conservation.

Willingness-to-Pay Seems to be Correlated with Water Quality. That is, people are willing to pay more to maintain water quality at a site with good water quality than at a site with poorer water quality. Over the range of water quality represented in the sample of sites, there are, therefore, increasing returns to water quality. This finding may be of significant practical importance in water quality planning since the incremental costs of water quality improvements tend to increase as higher levels of water quality are attained.

Finally, Where Water Quality Improvements Expand Recreation Opportunities, Adequate Facilities and Maintenance Must be Provided to Gain The Benefits. People are sensitive to beach cleanliness and minimal beach facilities, such as a changing room. These must be provided to gain the potential benefits of water quality enhancement. Coordination with parks and recreation departments, generally institutionally separated from water quality agencies, must be established and maintained, and adequate funds for these new responsibilities must be insured.

2. Methodology

Multiple Site Demand Models which Provide Exact Measures of Benefits as Measured by Consumer Surplus can be Specified. Traditional recreation demand studies ignore intersite substitutions; existing multiple site demand models do not meet the technical economic criteria for consumer surplus computations. A model which meets these conditions was specified. Estimation of its parameters was attempted but was unsuccessful. Methods for dealing with the attendant problems are outlined.

Factor Analysis can Effectively Reduce the Number of Dimensions of Water Quality, but the Resulting Factors are not Better "Explainers" of Recreation Behavior than the Variables From Which they are Drawn. Cross-sectional data on twelve water quality measures could be reduced to four factors which "explained" most of the variance in the data. These factors have natural interpretations. However, certain of the original variables perform as well as the factors in the statistical analysis relating water quality perception and recreation demand to water quality variables.

3. Avenues for Further Research

Why do People Care About Water Quality if they are not Sensitive to Consuming its Uses? This conservation ethic seems to be behind much contemporary environmental concern. Methods for measuring its value and weighing it in the political calculus could provide the basis for more efficient natural resource management. Further, a more precise statement of its nature might help clarify the issues concerning environmental preservation on one hand, and resource exploitation on the other.

Improved Methodology for Estimating System Demand Equations for a Large Number of Similar Goods is Needed. In the large, multi-equation techniques are very expensive and are capable of handling only a limited number of alternatives. The problem lies both in existing software, and the statistical techniques in use. In the small, further work on the model specified in this study could proceed by aggregating sites to some (much) smaller number of representative sites.

Finally, the Analysis Should be Extended to Non-urban Areas. While at present most of the nation lives in or close to major cities, there is some evidence that those demographic trends are shifting, and significant exurbanization has occurred during the late 1960's, and through the 1970's. How does this affect recreational needs and their relationship to water quality? Less urban areas typically have higher levels of water quality than urban areas, so the recreational usage may not be constrained by water quality, and conservation value may be less as well.

APPENDIX I. SITE FACILITY INVENTORY FORM

SITE CATALOG

1. Site Name ______________________________

2. Address ______________________________

3. Owner or Manager ______________________________

4. What fees are charged (list purpose & amount) _____

____

ACCESS & PARKING

5. Rapid Transit: route name/no. ______________

6. Bus: route name/no. ______________

7. Auto Road: route name/no. ______________

8. Distance to major highway (miles) ______________

9. Number of parking spaces ______________

SETTING

10. Urban ______________ Rural ______________

11. Surrounding Land Use

    a) low density residential (1 & 2 family homes)

    b) high density residential (includes multifamily buildings)

    c) commercial

    d) industrial

    e) agricultural

    f) natural

12. If Natural Land Use, select from below categories

a) not applicable

b) salt marsh or other wet lands

c) wooded or forest

d) mountainous of cliffs

13. Type of Body of Water

a) ocean or great lake

b) lake or pond

c) river

d) stream

SIZE

14. Water frontage (in feet) ____________________

15. Beach area ____________________

16. Water surface area (if appropriate) ____________

17. Total site area ____________________

BEACH CHARACTERISTICS

18. Material

a. sand

b. gravel

c. grass or ground cover

d. rocks

e. paving

19. Describe transition from land to water

a. gradual, sloping

b. abrupt

20. Describe nature of water bottom

a. muddy

b. sand

c. rocks

d. vegetation

21. Water movement

a. no movement

b. slow movement

c. rapid

22. Presence of flies or other insects

a. none b. some c. many

FACILITIES

23. What special facilities are available for swimming

a. bathhouse

b. raft or float

c. diving board

d. delimited swimming area

e. life guards (how many? ______)

f. other ____

24. What special facilities are available for boating?

a. marina

b. boat launch ramps (how many? _____)

c. boat rental facilities (what kinds of boats? ________________________________)

d. services and supplies

e. gasoline

f. other ________________________________

25. What special provisions or facilities are provided for fishing?

a. program of fish stocking

b. list type of fish ______________________

c. suppliers (of bait, etc.) ______________

26. What non-water based facilities are provided?

a. playground

b. game areas

number of tennis courts _____
number of ball fields_______
other _____________________

c. number of developed camp sites __________

d. amusement park or other facilities _______

e. number of miles of walking trails ________

USER CONVENIENCE FACILITIES

27. Which and how many of each of the following sanitary facilities are provided?

    a. drinking fountains ______________________

    b. sinks or water for washing ______________

    c. flush toilets ___________________________

    d. pit toilets _____________________________

    e. litter containers _______________________

EATING FACILITIES

28. What picnic facilities are available?

    a. size of area in acres ___________________

    b. number of picnic tables _________________

    c. number of fireplaces ____________________

    d. number of grills ________________________

    e. number of shelters ______________________

    f. total square feet of sheltered area ______

29. How far it it to the nearest

    a. Restaurant?

        1. on-site

        2. distance in miles ______________

    b. Concession Stand?

        1. on-site

        2. distance in miles ______________

29. c. Food Store?

1. on-site

2. distance in miles _____________

SITE USE

30. Are attendance or other usage data available?

yes no

31. Annual number of visitors _______________________

32. Number of visitors on a peak day ________________

33. What is the number of groups in 100 sq.ft. of site area? a. _______________ b. __________________

34. Estimate number of visitors _____________________

35. In your opinion, is this site crowded (scale of 1 to 3)? ___________________________

MAINTENANCE

36. Are any facilities in need of repair? List _______

____

37. In your opinion, is the site littered? (on a scale of 1 to 3) _______________

38. How often is trash removed and trash barrels emptied?

a. more than once a day

b. daily

e. less than daily

39. What is the number of pieces of litter in a 3 foot square area? Select three randcm areas

a. _______ b _________ c __________

APPENDIX II. WATER QUALITY SAMPLING

WATER QUALITY SAMPLING

Water quality samples were taken at all the sites over the two-day period, September 12-13, 1974. Both days were sunny with ambient day time air temperatures between 65° and 80°F. After rinsing the sample bottles with the water at the site, two one-liter samples were taken from a depth of approximately one foot in water at least three feet deep. The sample bottles were kept in an ice chest until delivered to the laboratory for analysis.

The analysis was performed by Eco-Control, Inc. of Cambridge, Massachusetts. The methods used to analyze the water samples for the parameters chosen were those recommended in the "Compendium of Analytical Methods" prepared in 1973 by the MITRE Corporation for the Environmental Protection Agency (PB-228 425). In general, the methods recommended come from "Standard Methods for Examination of Water and Waste Water," 13th Edition, American Public Health Association, Washington, D.C. (1971).

APPENDIX III. THE SURVEY INSTRUMENT

<u>SURVEY OF WATER-BASED RECREATION</u>

ID# _ _ _ _ _ _ _

CARD

PART I: PARTICIPATION IN WATER-BASED RECREATION

Hello, my name is _____, and I am taking a public opinion survey for Urban Systems Research and Engineering, Inc. I'd like to ask you some questions about the types of recreation you or members of this household participated in last summer, and the recreation areas you might have visited. (Last summer is the 15 weeks between Memorial Day--May 27--through Labor Day--September 2.)

(1) First of all, last summer in the Boston Area did any members of your household:

a. yes/b. no	Reasons	
__	__	A. go swimming
__	__	B. go boating
__	__	C. go fishing
__	__	D. go picnicking
__	__	E. go bicycling
__	__	F. go someplace especially to walk or stroll

If not, why not?

REASONS:
- a. not interested
- b. don't know how
- c. don't have the appropriate equipment
- d. too expensive
- e. water too dirty
- f. water too cold
- g. good places too crowded
- h. good places too far away
- i. don't own auto, good places can not be accessed by public transportation
- j. lack of time
- k. poor health
- l. other (please specify) ____________

__ __ G. What other types of recreation did members of your household engage in this summer?

____

(IF NO ACTIVITIES RECORDED, SKIP TO PART II, Q.2)

(2) The card shows some of the major fresh and salt water beaches in the Boston Area. Could you please tell me:

A. Which sites did you personally visit, and the number of times you visited each of those sites. Are there any sites which you visited which are not on this list? (Record those sites and the number of visits to each. Add visits and ask:)

So you personally visited a beach, lake or stream about ____ times this past summer?

B. Now I would like to find out about visits by anyone in this household to fresh and saltwater beaches in the Boston Area. Could you please tell me the number of visits by any household member to each of these sites. Are there any sites which you visited which are not on the list? (Record those sites and the number of visits to each. Add visits and ask:)

So members of this household visited a beach, lake or stream about ____ times this past summer.

C. About how long, on average, was spent at each of the sites you listed in the two questions above?

a. less than one hour
b. over one hour but less than three hours
c. over three hours but less than six hours
d. more than six hours

(3) <u>Travel</u>:

A. For each site visited, how did you get there?

a. walking
b. bicycle
c. automobile
d. bus
e. subway
f. taxi
g. other ___________

B. About how long does it take to get there that way? (in minutes)

C. How much does it cost to get there?

If by bus or subway or taxi, how much is the roundtrip fare? If by auto what was the price of tolls? (the total cost for the visiting group)

(4) Expenditures:

For each site, about how much does it cost when your party goes there? (total cost for the group)

parking
entry
food
liquor
other (including rentals, gasoline for boats, etc.)

Add and Record Total/Visit

(5) For each site about how many people from your household, on average, make the trip?

(6) Activities:

For each site you visit what activities do you participate in? (Record the most important activities up to three.)

a. swimming
b. boating
c. fishing
d. sunbathing
e. strolling
f. bicycling
g. picnicking
h. other ____________

(7) If the respondent did not visit the closest site, ask:

__________ beach is the major recreation site closest to your home, yet you did not mention having visited it. Why not?

REASONS:
a. not aware of that site
b. do not like the facilities
c. to crowded
d. beach too dirty
e. water to cold
f. water too dirty
g. don't own auto, not accessible by public transportation
h. too expensive
i. not interested in the activities available there
j. other (please specify) ____________

PART II: PERCEPTION

(1) For each site you visited would you please rate it on a scale from 1-5. For this rating, 1 means bad, 2 is moderately bad, 3 is fair, 4 is moderately good, and 5 is good.

A. water temperature
B. water quality (clarity, color, weeds, odor, etc.)
C. beach facilities (availability)
D. beach quality (setting, maintenance)
E. crowding

(2) Are there any sites with which you are familiar, but did not visit this summer? If so, which are they and would you please rate in a similar fashion those sites.

(3) Are there any sites which you have visited this or other seasons, or are familiar with, which you do not intend to visit again? If so, please list the sites and why you do not intend to use them.

Site #	Reasons
--	—
--	—
--	—

REASONS:
a. too crowded
b. too far away
c. too expensive
d. water too cold
e. water too dirty
f. beach too littered
g. poor beach facilities
h. non-auto access too poor
i. change in activities
j. other (please specify) ____________

(4) Let's talk about the beach, lake, or river site you visited most. That was ________, site number ___.

Site #	Reason
--	—

A. Why do you visit this site most often?

REASONS:
a. it is close
b. it is cheap
c. the water temperature is nice
d. the water quality is good
e. my family always came here
f. not too crowded
g. nice setting
h. beach is clean
i. nice facilities
j. my friends go there
k. other ____________

___ B. If water quality became much worse (declined to a ranking of 1) what would your response be?

a. still visit the same beach as much
b. visit that site less frequently and some other site more (specify which one)
c. visit that site less frequently and participate in some other non-water-based recreation more (specify which activity)
d. participate in outdoor recreation less, no change in other leisure
e. participate in outdoor recreation less, and indoor recreation more

___ C. If beach facilities became much worse (declined to a ranking of 1) what would your response be?

a. still visit the same beach as much
b. visit that site less frequently and some other site more (specify which one)
c. visit that site less frequently and participate in some other non-water-based recreation more (specify which activity)
d. participate in outdoor recreation less, no change in other leisure
e. participate in outdoor recreation less, and indoor recreation more

___ D. If beach quality became much worse (declined to a ranking of 1) what would your response be?

a. still visit the same beach as much
b. visit that site less frequently and some other site more (specify which one)
c. visit that site less frequently and participate in some other non-water-based recreation more (specify which activity)
d. participate in outdoor recreation less, no change in other leisure
e. participate in outdoor recreation less and indoor recreation more

___ E. If crowding became much worse (declined to a ranking of 1), what would your response be?

a. still visit the same beach as much
b. visit that site less frequently and some other site more (specify which one)
c. visit that site less frequently and participate in some other non-water-based recreation more (specify which activity)
d. participate in outdoor recreation less, no change in other leisure
e. participate in outdoor recreation less and indoor recreation more

___ F. If this site were closed, what would your response be?

a. visit the site that you now visit second most often and still go to the beach as often as before
b. visit second most frequently visited site more, but reduce total number of visits
c. visit all sites now visited more, but reduce total number of visits
d. participate in non-water-based outdoor recreation more (specify which activity)
e. participate in outdoor recreation less, no change in other leisure
f. participate in outdoor recreation less and indoor recreation more

___ G. How much could the cost of visiting this site be raised before you started visiting your second most favorite site more?

a. $.50
b. $1.00
c. $2.00
d. $3.00
e. $4.00
f. $5-10.00
g. more than $10.00

___ H. Suppose that this site were to become very polluted and the water quality would be reduced to a ranking of 1. This could be avoided if sufficient funds were raised to pay for the necessary clean-up. If these funds were to be raised through an entrance fee, what is the most you would be willing to pay to prevent this decline in water quality?

a. $.50
b. $1.00
c. $2.00
d. $3.00
e. $4.00
f. $5-10.00
g. more than $10.00

___

I. Suppose that the water quality could be made much better (improved to a ranking of 5) if sufficient funds were raised to pay for the necessary clean-up. If these funds were to be raised through an entrance fee, what is the most you would be willing to pay to achieve the water quality improvement?

a. $.50
b. $1.00
c. $2.00
d. $3.00
e. $4.00
f. $5-10.00
g. more than $10.00

1st ___
2nd ___
3rd ___

(5) In choosing a site what is the most important characteristic? 2nd most important? 3rd most important?

a. presence of a bathhouse/changing room
b. absence of litter
c. presence of a lifeguard
d. presence of a marine/boat launching facility
e. stocked game fish
f. a natural setting
g. water temperature
h. water appearance
i. presence of other beach facilities
j. cost (parking fees, entry fees)
k. proximity
l. where your friends go
m. where your family always went
n. other ___________________

1st ___
2nd ___
3rd ___
4th ___
5th ___

(6) Thinking of water quality, the attractiveness of the water for swimming depends on the color, odor, clearness, amount of floating debris or scum, and the amount of aquatic weeds. Which characteristic is the most important? 2nd most important? Please rank these characteristics.

a. color
b. odor
c. clearness
d. floating debris
e. aquatic weeds

___ (7) What is your favorite water-related activity?
DO NOT READ RESPONSES

a. swimming
b. boating (canoeing, sailing, etc.)
c. fishing
d. wading
e. water skiing
f. picnicking by water
g. bicycling by water
h. walking/strolling by water
i. other (please specify) ____________

1st ___
2nd ___
3rd ___

(8) What other recreation activities have members of your household engaged in this summer? (rank according to preference) DO NOT READ RESPONSES

a. swimming, in a pool
b. tennis
c. field sports (softball, baseball, football)
d. basketball
e. golf
f. picnicking
g. walking for pleasure
h. bicycling
i. outdoor spectator sports
j. indoor recreation activities
k. other (please specify) ____________

1st ___
2nd ___
3rd ___

(9) Of all the recreational activities we have discussed, including both those related to water and those not, what do you do most often? 2nd most often? 3rd most often?

a. swimming
b. boating
c. fishing
d. wading
e. water skiing
f. other water-based (please specify) ________
g. swimming, in a pool
h. tennis
i. field sports (softball, baseball, football)
j. basketball
k. golf
l. picnicking
m. walking for pleasure
n. bicycling
o. outdoor spectator sports
p. indoor recreation activities
q. other non-water-based (please specify) _____

(10) Among the water-based activities covered in this interview, are there any which you would enjoy doing but do not get to as much as you would like to in the Boston Area?
(Record Response Below)

PART III: PERCEPTION

(1) How many people are in the household? Could you tell me how many fall into each age category?

Number

	Age Range
A.	0-6 (pre-school)
B.	7-13 (elementary school-junior high)
C.	14-17 (high school/too young to drive)
D.	18-25 (college age)
E.	26-65
F.	65

(2) Who is the Respondent?

A. Sex -- a. male
b. female

B. In which of these groups is your own age?
- a. 0-6 (pre-school)
- b. 7-13 (elementary school-junior high)
- c. 14-17 (high school/too young to drive)
- d. 18-25 (college age)
- e. 26-65
- f. 65

C. Which of these best describes your status in this household?
- a. grandparent
- b. father
- c. mother
- d. sibling
- e. other relative
- f. live alone or with unrelated individuals

___ (3) Which letter corresponds to the total household (including children) annual income after taxes, in other words, the total take-home pay?

a. 0-4999
b. 5000-7499
c. 7500-9999
d. 10,000-12,499
e. 12,500-14,999
f. 15,000-19,999
g. 20,000-24,999
h. 25,000-29,999
i. 30,000-34,999
j. 35,000-40,000
k. greater than 40,000

___ (4) What is the occupation of the principal income earner?

a. Professional, Technical, and Kindred
b. Managerial
c. Production Superintendent/Foreman
d. Skilled Laborer
e. Unskilled or Semi-skilled
f. Clerical/Secretarial
g. Retired
h. Student
i. Housewife
j. Other (please specify) ________________

___ (5) What is your occupation?

a. Professional, Technical and Kindred
b. Managerial
c. Production Superintendent/Foreman
d. Skilled Laborer
e. Unskilled or Semi-skilled
f. Clerical/Secretarial
g. Retired
h. Student
i. Housewife
j. Other (please specify) ________________

___ (6) What is the highest level of educational attainment represented in the household?

a. elementary/junior high school
b. some high school
c. completed high school
d. some college (including junior college)
e. vocational/technical school
f. completed college
g. post-graduate

__ (8) What is the last grade in school you yourself completed?

a. elementary/junior high school
b. some high school
c. completed high school
d. some college (including junior college)
e. vocational/technical school
f. completed college
g. post-graduate

(9) Do you own any of the following equipment? If so, please estimate its approximate original retail cost and the year purchased.

Original Retail Cost	Year Purchased	Item
$_, ___	__	A. Boat
$_, ___	__	B. Outboard Motor
$_, ___	__	C. Boat Trailer
$_, ___	__	D. Other Boat Equipment
$ ___	__	E. Fishing Tackle (rod, reel, tackle box, etc.)
$ __	__	F. Fishing Licenses
$ ___	__	G. Backpack
$ ___	__	H. Waterskis
$ ___	__	I. Special Clothing (wetsuit, waders, etc.)
$ ___	__	J. Bicycle
$ __	__	K. Cooler
$_, ___	__	L. Other Items (please specify) ____________

(10) Leisure Time

__ A. How many days per week does the principal income earner usually work?

a. less than four
b. four
c. five
d. six
e. seven

__ B. How long is his or her paid vacation (# weeks)?

a. none
b. up to one week
c. over one week, up to two weeks
d. over two weeks, up to three weeks
e. over three weeks, up to one month
f. over one month, up to two months
g. over two months

___ (10) Do you own an automobile? If yes, how many?

a. No, none
b. Yes, 1
c. Yes, 2
d. Yes, 3
e. Yes, more than 3

___ (11) A. How often do you or anyone in this household use public transportation? (highest level in household)

a. never
b. almost never
c. occasionally
d. frequently

___ B. About how far away is the nearest subway or bus stop?

a. 1 block (1/8 mile)
b. 2 blocks (1/4 mile)
c. 3 blocks (3/8 mile)
d. 4 blocks (1/2 mile)
e. more than 1/2 mile

___ (12) How would you describe your ethnic background?

____

RECORDING FORM

SITES	PERSONAL VISITS 2a	HOUSEHOLD VISITS 2b	DURATION 2c	TRAVEL MODE 3a	TRAVEL TIME 3b	TRAVEL COST 3c	EXPENDITURE 4	GROUP SIZE 5	ACTIVITIES 6 1st	2nd	3rd	1 or 2 a	b	c	d	e
1. Kings Beach (Swampscott)																
2. Lynn Beach (Lynn)																
3. Nahant Beach (Nahant)																
4. Revere Beach (Revere)																
5. Short Beach (Revere)																
6. Winthrop Beach (Winthrop)																
7. Constitution Beach (Orient Heights) Beach (Boston)																
8. Castle Island (Boston)																
9. Pleasure Bay (Boston)																
10. City Point (Boston)																
11. L & M Street Beaches (Boston)																
12. Carson Beach (Boston)																
13. Malibu (Savin Hill) Beach (Boston)																
14. Tenean Beach (Boston)																
15. Wollaston Beach (Quincy)																
16. Nantasket Beach (Hull)																
17. Wingaersheek Beach (Gloucester)																
18. Crane's Beach (Ipswich)																
19. Plum Island (Newbury)																
20. Duxbury Beach (Duxbury)																
21. White Horse Beach (Plymouth)																
22. Breakheart Reservation (Saugus)																
23. Sandy Beach (Upper Mystic Lake) (Winchester)																
24. Houghton's Pond (Blue Hills Reservation) (Milton)																
25. Wright's Pond (Medford)																
26. Walden Pond (Concord)																
27. Stearns Pond (Harold Parker State Forest) (Andover)																
28. Cochituate State Park (Natick)																
29. Hopkinton State Park (Hopkinton)																
30. Esplanade/Storrow Lagoon (Boston)																
31. Charles River, between Weeks and Anderson Bridges (Cambridge)																
32. Spy Pond (Arlington)																
OTHER (please specify) 33. ______																
34. ______																

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16. ABSTRACT

Considerable past work has attempted to estimate the recreational benefits which might accrue from water quality improvements. The theoretical underpinnings of this work, however, are becoming increasingly suspect. This report explores demand models, new to recreational analysis, which are based on site characteristics and individual preferences to estimate benefit measured by consumer's surplus.

The empirical findings of this study are based on a structured survey of 467 representative households in the Boston SMSA. Our focus was specifically day trips to a system of Boston area beaches, but considerable additional data on willingness-to-pay, substitution between sites and activities, water quality perception and general recreation behaviour was developed as well. The reader will find an extensive review of the post-war literature on recreation economics and water quality benefits.

17. KEY WORDS AND DOCUMENT ANALYSIS

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