

# VALUING BEACH RECREATION LOST IN ENVIRONMENTAL ACCIDENTS

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**ABSTRACT:** This paper reviews methods that can be used to estimate the loss in use value associated with saltwater beach recreation in the case of an environmental accident, such as an oil spill. Particular attention is focused on methods for verifying beach attendance data and on transferring benefit estimates from other locales. The paper first reviews methods for estimating what reported attendance might have been had the accident not occurred. The next issue considered is how to verify reported attendance data and how to correct it when systematic inaccuracies are found. The paper then turns to the question of valuing a beach visit and reviews the relevant empirical literature.

## INTRODUCTION

It is common for environmental accidents to temporarily restrict ocean recreation opportunities. The *Amoco Cadiz* oil spill in 1978 damaged beaches in Brittany (Brown et al. 1983). The monetary value of lost beach recreation was part of the damages assessed against Amoco. In 1990, the *American Trader* oil tanker spilled oil just off Huntington Beach, immediately south of Los Angeles, closing some of the most visited beaches in the United States for a period of several weeks or more (Chapman et al. 1998; Dunford 1999). Again, the value of lost beach recreation was a major factor in assessing damages against those responsible for the spill. In the late 1990s several beaches in Santa Barbara County, Calif., were closed to swimming and other water contact sports for a period of several weeks. In this case the cause was bacterial contamination from storm runoff through creeks. Thus, estimating the value of value lost beach recreation would be an important step in formulating a policy concerning the abatement of waterborne bacterial loads.

Although much has been done to improve methods for valuing recreation and other nonmarket environmental goods (Braden and Kolstad 1991; Freeman 1993; Kolstad 2000), there is little published on the practical steps needed to generate an estimate of lost recreation value due to a closure. The purpose of this paper is to detail some of the issues that must be faced in generating damage estimates.

The typical situation in the case of an accident that affects beach use is that attendance drops, possibly to zero, during the affected period. After the beach reopens, the beach experience may be degraded for those who do attend. Furthermore, not all beach visits are the same. The second visit in a week for an individual is probably not worth as much as the first visit. Visits of different duration may be valued differently—a two-h visit is not equivalent to two 1-h visits. Conceptually, the correct way to view the value of lost beach visits is to first measure the surplus loss to an individual and then aggregate over the population of individuals. This can be very difficult.

Practically speaking, the typical way of viewing damages has been to consider that all visits have the same value and that total damage is the product of price (average value) and quantity (number of visits lost). The relevant academic literature has focused almost exclusively on the price component of this product (i.e., on valuation) and paid little attention to the quantity component. However, as subsequently shown, es-

timating quantity also presents practical and conceptual challenges. One must attempt to estimate how many visits would have been made if the closure had not occurred. Inevitably, this requires the use of reported data on beach visitation for periods when the beach was open. As emphasized later, in cases where no admission fee or parking fee is charged and access is largely unrestricted, the task of measuring the number of visits is very difficult. In these situations the quality of reported visitation data is naturally open to question, and assessing the accuracy of visitation data becomes an important part of the analysis.

## BEACH ATTENDANCE

The first question to ask is how much would the beach in question have been used *but for the accident*? This is not an easy question to answer quantitatively. There are three time periods to be concerned about: (1) The period when the beach is officially closed, for cleanup purposes or for public health reasons (closure period); (2) the period when the beach is open, but the experience is degraded because there is still evidence of pollution (physically degraded period); and (3) the period when the beach is physically clean, yet the memory of the accident is fresh enough that the quality of the experience may be somewhat degraded (perceptually degraded period).

Normally, researchers can only deal with lost attendance during beach closure or possibly in the period immediately following beach closure. Because daily beach attendance fluctuates dramatically and for a large variety of reasons—an interesting sports broadcast on local TV can dramatically reduce attendance—it is difficult to estimate what the attendance might have been if the beach had not been closed. Although it is desirable to estimate lost attendance during the physically and perceptually degraded periods, that is often not possible.

To estimate beach attendance but for the accident, one must answer two basic questions: what would reported attendance have been but for the accident, and does actual attendance differ systematically from reported attendance? As will be discussed later, these are two very different questions, and the second question regarding data accuracy can be very important. For beaches with controlled access, such as through parking lots and entrance booths, estimating actual attendance on any given day is straightforward and generally accurate. However, many beaches do not have limited access points but are bounded by a boardwalk or path adjacent to shops and other urban amenities. Measuring the number of beach visits at such beaches is difficult and is subject to more error.

Most well attended beaches maintain attendance records, often daily. In California, this applies to beaches at state parks as well as many municipal beaches. To estimate the damage from an accident, one must estimate what the reported attendance would have been had the accident not occurred and how much reported attendance estimates differ from actual attendance. These two issues are considered below.

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## **“But For” Reported Attendance**

The first question, “What would reported beach attendance have been but for the accident?” is best viewed as an economic question. Given daily—or perhaps weekly or monthly—data on attendance covering a substantial historic period, a model of beach attendance can be estimated. This model can then be used to simulate the counterfactual of the affected beach being open.

Conceptually, beach attendance is complex. Whether someone goes to the beach depends on what other recreation opportunities are available, including sports events on and off television, weather, activities at the beach and elsewhere, the opportunity cost of the visit, and other factors including how many recent opportunities there have been to attend the beach. Although it is possible that an intuitively clear behavioral model of beach attendance (a structural model) could be constructed, it is not easy to represent the beach choice problem, particularly when there are a number of close substitutes. A reduced-form time-series approach is easiest to implement and probably most practical.

In constructing a model of beach attendance at the southern Los Angeles area beaches in the context of the *American Trader* oil spill, Ruud (1994) estimated a vector autoregressive (VAR) model of attendance; attendance is affected by contemporaneous variables, such as weather, day of the week, and season, but also lagged attendance at the beach and at other beaches. VAR models are commonly used in macroeconomic forecasting. Including lagged attendance reflects the fact that errors from examining only contemporaneous variables will tend to be temporally autocorrelated (Ruud 1994; Dunford 1999). All other things being equal, if yesterday was a day that attracted a large number of beach visitors, then it is likely that today will also attract many beach visitors.

One problem with using a VAR model to simulate the counterfactual is that models usually use lags of a few days—the previous day or the previous week. But observations on these lagged beach visits, absent the accident, are unavailable. Thus it is important to try to include as many appropriate contemporaneous variables as possible and to use lagged attendance at beaches outside of the accident area rather than within the accident area. (Using beaches outside of the accident area is not totally satisfactory as their attendance may be increased by beach closure at the study site.) However, this may not always be feasible. The less desirable alternative, of using forecast attendance at the study site and lagging it for subsequent forecasting, can cause errors to be compounded. Dunford (1999) discussed this issue in the context of Ruud’s model.

As was mentioned earlier, another issue concerns the duration of the damage period. This is not a significant issue when the beach is completely closed. But in other cases the beach may be closed only to some activities (e.g., swimming and surfing). Also, after the beach opens, the quality of a visit may be degraded, or people may not be immediately aware that it has reopened. Clearly, there is some period of time immediately following actual closure when one can expect attendance to be reduced.

## **Correcting Reported Attendance**

Reported beach attendance may not correspond to actual beach attendance, and actual beach attendance clearly is what is needed to estimate damages. Thus the second step, and the one considered in this section, is to identify and correct for any systematic discrepancy between reported and actual beach visitation.

In this regard, beaches can be separated into two types: those with limited access and those without limited access.

Limited access beaches have restricted entry points where one can observe entry and exit. Open access beaches on the other hand are freely accessible; thus observing entry and exit is difficult at best. Each type of beach requires a different approach for verifying and, if necessary, correcting reported attendance.

### *Limited Access Beaches*

For limited access beaches, parking is often monitored to generate attendance estimates. For state beaches in the Los Angeles area, authorities generally charge for parking and thus have fairly accurate counts of the number of cars “using” a particular beach. Authorities make assumptions regarding the average number of occupants per vehicle as well as the average ratio of “walk-ins” to vehicles. To the extent that assumptions about these ratios and averages are based on observation, this is a reasonably accurate and cost-effective way to estimate attendance. Problems arise when walk-ins and automobiles are not highly correlated. Further problems arise from people who walk along a beach, because it is difficult to exclude entry near the shoreline. In assessing the accuracy of reported attendance at limited access beaches, it is important to verify that the car counts are accurate, that the assumed occupancy rate is accurate, and that the ratio of walk-ins to automobiles is accurate. Accuracy can be judged by random sampling of individuals on the beach or of individuals arriving at the beach. If the underlying assumptions are not accurate, the analyst can correct reported attendance figures appropriately.

### *Open Access Beaches*

Attendance at open access beaches is more difficult for authorities to measure and more difficult for the analyst to verify. This was illustrated in the controversy over the National Park Service’s estimate of participation in the “Million Man March” on the Mall in Washington on October 16, 1995. The Park Service estimated attendance at 400,000, whereas the organizers estimated attendance at 2,000,000. Subsequent analysis of aerial photos by Boston University placed the figure between 700,000 and 1,000,000 (Daly and Harris 1995). It is not easy to estimate the size of crowds.

This suggests that aerial photos are one reliable way to estimate the number of people over a large area. However, aerial photos are prohibitively expensive as a way to generate regular estimates of attendance. At Newport Beach, Calif., lifeguards are asked to estimate attendance at different points in time during a day, and from these estimates beach attendance is computed. Huntington City Beach, Calif., another open access beach, also uses lifeguards to estimate attendance, though relying more heavily on car counts in parking lots (Chapman et al. 1998).

To verify attendance, one could take aerial photos of the beach at different points in time during a day and count the number of people in the photos. A problem, however, is that aerial photos only give the number of people at a certain point in time, not the number of visits. One can, however, estimate the number of distinct visits by combining information on the number of visitors at various points in time with information on the duration of visits, obtained from surveying at the beach. The basic idea is simple. If one knows the number of people on the beach as a function of time throughout the day, the total number of “person-hours” at the beach can be computed by integrating this function over the day. Dividing person-hours by the average duration of a visit (obtained from a survey) then gives the number of separate visits.

One problem is that some people may stay longer than others and thus may be oversampled in determining visit duration.

**TABLE 1. Reported Attendance versus Attendance Estimated from Aerial Photographs**

Beach (1)	Date (2)	Mean visit duration (3)	Maximum number of visitors <sup>a</sup> (4)	Reported visits (5)	Estimated visits <sup>b</sup> (6)	Estimated/ reported visits (7)
Huntington City	February 17, 1995 (Friday)	1.91	814	6,242	2,676	0.43
	February 18, 1995 (Saturday)	2.73	4,319	22,132	9,631	0.44
Newport	February 17, 1995 (Friday)	1.75	1,241	14,000	4,225	0.30
	February 18, 1995 (Saturday)	2.59	6,233	75,000	15,529	0.21

Note: Sample size for computing duration: Huntington City, 74 (February 17) and 131 (February 18); Newport Beach, 107 (February 17) and 117 (February 18). The weekend of February 18 was a holiday (President's Day) and the weather was warm and sunny.

<sup>a</sup>Maximum quantity of people on the beach at any one time is assumed to be the number of people counted on 1:30 p.m. aerial photo and mean visit duration is in hours.

<sup>b</sup>Estimated attendance is computed using aerial photographs and surveys of visit duration, as described in text.

Appendix I describes a method for combining aerial photos with an on-site survey of visit duration to estimate an overall number of beach visits.

Table 1 shows the results of this calculation for Newport Beach and Huntington City Beach, two beaches south of Los Angeles, for 2 days in 1995. Table 1 also shows attendance figures reported by the government agencies that operate those beaches, using the lifeguard count methods described earlier. Evidently, the lifeguard counts significantly overstate actual attendance. On the busiest day at Newport Beach, reported visitation exceeds the estimate based on aerial photos by a factor of almost 5. Aerial photos were taken on three other days, though surveying was not done on those days. Using duration data reported in Table 1, a discrepancy between actual and reported attendance is evident in the three additional aerial photo days as well. The survey instrument used to generate the duration data is available from the writers upon request.

## VALUATION METHODS

There are two general approaches to monetizing the value of lost beach visits. One is to use what has become known as benefits transfer. This involves surveying the literature on empirical analyses of the value of similar goods. Based on this literature, an inference is drawn about the value of a lost recreation day at the beach being considered. The second approach is to conduct a valuation study at the beach subject to closure. This can be expensive but has the obvious advantage of applying directly to the beach of interest.

### Empirical Methods for Valuing Beach Recreation

There are two basic empirical methods for valuing beach recreation, contingent valuation and travel cost. Contingent valuation involves surveying beach visitors. These surveys include questions such as "If, in order to maintain beach quality, it became necessary to institute a fee of \$9/day to visit this beach, would you continue to visit?" By comparing responses to such questions with characteristics of the respondent and varying the reservation fee proposed, estimates of willingness to pay for a beach visit can be deduced, at least in principle.

A second empirical approach to valuing beach recreation involves determining how travel costs affect beach visits. This is a widely used method, dating back to the 1940s (Braden and Kolstad 1991; Kolstad 2000). If one can observe the cost an individual bears when making a beach visit, one may infer that the visit must have been worth at least as much as the cost. Thus, travel cost plays the role of a price, and demand may be estimated. While the basic premise is valid, the travel cost method is not without problems. At least three issues arise in implementing the travel cost method for determining the value of lost beach recreation. One concerns the sampling frame. Should visitors to the beach be sampled, which is the common approach, or should the population of possible visi-

tors be sampled, which is a much more costly but less problematic approach (Hausman et al. 1995). Second, how should one deal with the value of travel time? Certainly it is related to an individual's wage, but does it equal the wage? What about children and the unemployed? The dollar value individuals assign to time spent traveling in vehicles has been studied intensively. Economic evaluation of new rapid transit systems has motivated much of this work, as reduction in travel time is the main benefit of such systems. This extensive literature has been reviewed by others and broad generalizations on the value of time spent traveling have emerged. Heilbrun (1993) concluded that "individuals value travel time at not more than half their wage rate." Sullivan (1991) generalized from empirical studies of urban transit that "commuters value time spent in the transit vehicle at about one third to one half the wage."

A third issue concerns the treatment of a visit. Considering visit duration explicitly is important because visits of different length probably are not equally valuable, and those traveling a long distance to the beach are likely to stay longer.

These problems are particularly difficult in the case of multi-day and multipurpose trips, where it becomes difficult to associate specific components of travel cost to specific recreation activities. For instance, if someone travels from the United States to Barcelona for 3 weeks, visiting beaches and museums and enjoying Spanish food, art, and culture, it may be difficult to measure the value of a beach day in Barcelona based on total travel expenditures. The travel cost method is better suited to single purpose trips of short duration.

An important issue in any recreation valuation study is the treatment of substitutes. If a perfect substitute beach exists, then the damage from being excluded from the closed beach cannot exceed the travel cost to the substitute. Even if the alternative beach is not a perfect substitute, it can still limit surplus loss from the closed beach. However, estimating demand for several sites that are imperfect substitutes is difficult.

A further complication is temporal substitution. Temporary closure may cause a beach visit to be deferred by several weeks, but not lost permanently. It is unlikely that deferred visits and permanently lost visits are equally costly. That is, valuation studies usually consider only the permanent addition or permanent subtraction of beach recreation opportunities. However, an accident causes temporary loss of recreation opportunities, and consumers may respond by substituting across time, postponing visits until the beach reopens. To what extent do consumers substitute across time? If the delayed beach visit is a perfect substitute, then there is no loss from the temporary closure. It is likely that visits at different points in time are only imperfect substitutes, however, which brings us back to the difficult estimation issues associated with spatial substitution. A paper by Smith and Palmquist (1994) is one of the few papers that deals with temporal substitution.

An additional concern is the loss associated with degraded

Description [Including state and date of data]	Original Value (\$ per beach-day)	Value in 1990 \$
CONTINGENT VALUATION ESTIMATES:		
<u>Bell and Leeworthy (1986)</u> CV Approach [3/1984, Florida]		
Mean	\$1.31	\$1.63
Median	\$0.33	\$0.41
Marginal	\$0.77	\$0.96
<u>Binkley and Hanemann (1978)</u> [12/1974, Mass.]		
WTP1 (Mean, Median)	\$1.98, \$1.08	\$4.88, \$2.66
WTP2 (Mean, Median)	\$2.08, \$1.24	\$5.13, \$3.06
WTP3 (Mean, Median)	\$2.03, \$1.24	\$5.01, \$3.06
<u>McConnell (1977)</u> [8/1974, Rhode Island]		
at 60° F	\$0.37	\$0.95
at 70° F	\$0.78	\$2.00
at 80° F	\$1.68	\$4.30
NOAA (Leeworthy et al, 1989-94)--median [1988-90, Northeast, Florida, Pacific Coast]		
Cabrillo-Long Beach/Santa Monica	\$1.12-1.89	\$1.16-1.95
Other Southern California beaches	\$1.00-5.22	\$1.03-5.39
Florida	\$1.85-2.38	\$1.91-2.46
All U.S.	\$2.09-4.31	\$2.16-4.45
TRAVEL COST ESTIMATES:		
<u>Bell and Leeworthy (1986)</u> Travel Expenditures [9/1983, Fla.]		
Average	\$10.23	\$13.00
Marginal	\$1.08	\$1.37
<u>Moncur (1975)</u> [8/1972, Hawaii]	\$0.35-\$1.37	\$1.07-\$4.18
<u>Bockstael, McConnell and Strand (1988)</u> [1984, Mass.]		
Range, six beaches	\$1.24-10.19	\$1.53-12.55
Mean, six beaches	\$3.23	\$3.98
<u>McConnell (1992)</u> [11/1984, Massachusetts]	\$0.58-0.94	\$0.70-1.14
<hr/> Note: Certain studies identified were excluded from our review and from this figure due to limitations with the data or methodology used. These are: Dornbusch & Co. (1982), U.S. Army Corps of Engineers (1981, 1993), Curtis and Shows (1982), and Silberman and Klock (1985).		

**FIG. 1. Summary of Identified Saltwater Beach Valuation Studies**

beach visits. If the quality of a beach visit can be quantified (e.g., if pollution levels are observed), then it may be possible to estimate the surplus loss from a degraded visit. Such quality considerations have been introduced in some studies, as noted shortly, but not in the context of environmental accidents (McConnell 1977; Binkley and Hanemann 1978).

### Benefits Transfer

An inexpensive approach to estimating the value of a lost beach visit is to transfer an estimate of the value of a lost visit prepared for another context to the beach of interest. Basically, one surveys the literature on beach recreation and generates a best estimate of the value of a visit at the beach in question. To assist in using benefits transfer, a review of benefit estimates for saltwater beach recreation (current through 1995) is provided.

A word of caution is in order in conducting benefits transfer. One must be aware of the nature of the good being valued.

With a beach visit, is this a summer visit, a winter visit, a day trip or a multiday trip? Is the visit primarily to use the beach or to use the water? Should the analysis include boaters, surfers, and whale watchers? Clearly, these questions must be addressed when transferring benefit estimates from elsewhere.

There appear to be 13 relevant studies of the value of saltwater beach recreation. All use either the contingent valuation (CV) or travel cost approach. A number of other studies of water recreation or the value of water quality improvements at recreation areas were also identified. However, they are less useful for determining the value of a lost saltwater beach recreation day for residents.

Fig. 1 summarizes the values estimated for a beach day visit in the studies examined. The figure shows the original values taken directly from the studies and values inflated to common (1990) dollars using the consumer price index. When reviewing Fig. 1, keep in mind that each of these studies was done in a different context, and so they may not be directly comparable.

The majority of these studies used the CV method. Although quality is always an issue in economic analysis, this is particularly important with CV studies, because the nature of the survey instrument can significantly shape the results obtained. To provide guidance as to the validity of the CV method and to outline proper protocols to use in CV studies, the U.S. National Oceanic and Atmospheric Administration (NOAA) convened a "blue-ribbon" panel of experts to conduct an independent review of these issues (the "NOAA Panel"). The panel, convened in 1993, concluded that CV can provide useful information, but surveys should be constructed with considerable care (NOAA 1993). These findings were subsequently embodied in NOAA regulations on the conduct on Natural Resource Damage Assessments [see 61 Fed. Reg. 440, January 5, 1996, codified at 15 CFR, and Jones (2000)]. The guidelines are detailed and include such general recommendations as using referenda rather than open-ended questions, using personal rather than mail surveys, and carefully pretesting the survey instrument. Most of the CV studies reviewed here predate these guidelines. The state of the art of CV has evolved considerably over the last two decades.

To shed light on the context in which these studies were conducted, as well as the strengths and weaknesses of the methods used, some of these studies are reviewed below. The discussion is divided into two major categories of analysis: contingent valuation and travel cost.

## Survey of Empirical Studies

### *Contingent Valuation*

There are a number of contingent valuation studies of the value of beach recreation. Binkley and Hanemann (1978) published an analysis of the value of beach recreation and water quality improvements for beaches in the Boston area. This is among the more carefully designed and executed studies of beach recreation available and thus warrants close examination.

Binkley and Hanemann collected data on beach recreators in the Boston area by administering approximately 500 in-person interviews in December 1974. The survey instrument included a large variety of questions on beach use. The authors were interested in estimating a model of site demand that explicitly considered choice among alternative beaches. Thus they asked questions of the following nature (the questions are paraphrased):

1. How many times during the past summer did anyone in your household visit specific beaches in the Boston area?
2. How long did it take for you to get to each beach and how much did it cost for you to travel there and back?
3. Why do you visit           (site name)           most often?
4. If this site became much more polluted, what would your response be?
5. How much would the cost of this site have to be raised before you would start visiting your second most favorite site more? (WTP1 in Fig. 1)
6. Suppose your favorite beach were to become very polluted. This could be avoided if sufficient funds were collected. How much would you pay to prevent this deterioration in water quality? (WTP2 in Fig. 1)
7. Suppose that, with appropriate funds, the water quality of your favorite site could be dramatically improved. What is the most you would be willing to pay for this? (WTP3 in Fig. 1)

Although Binkley and Hanemann collected travel cost information, including time, they did not calculate travel cost or carry out a travel cost analysis of the value of a beach-day.

An interesting feature of this study is its emphasis on substitute sites. Binkley and Hanemann asked a series of questions with the obvious intent of learning why one site is chosen over another. For instance, Question 3 seeks to determine why the respondent chose the most commonly visited beach. The most frequent response to this question is proximity (47.5% of respondents). The second most frequently cited reason (12.3% of responses) is that the respondent's friends go there. A lack of crowding was the most important factor for only 3.6% of respondents. The importance of proximity suggests that the effort involved in traveling is a major determinant in deciding which beach to visit.

In response to Question 4 above, 56.9% of the respondents said they would switch to another site should their favorite site become very polluted. This suggests the important role of other beaches as substitutes when one's preferred site becomes unavailable or unattractive.

In what was basically a CV study, Binkley and Hanemann used several different questions to elicit willingness-to-pay. They first asked the willingness-to-pay to move to the respondent's second favorite site (WTP1). This should provide an estimate of the incremental value of the favorite beach. The authors also asked two other questions related to water pollution: how much the respondent would be willing to pay to avoid increased pollution (WTP2), or to improve water quality from the current state (WTP3).

In another interesting study, also done in the 1970s, McConnell (1977) surveyed visitors at Rhode Island beaches in order to measure willingness-to-pay for beach visits and the effect of crowding. A series of questions was posed to the beach-goer involving a hypothetical price and whether he or she "would come to the particular beach on the particular day for that price?" with the suggested price sequentially incremented by \$0.50. Thus a series of yes/no responses is collected, resulting in a CV estimate of maximum willingness-to-pay. Other information was collected in the surveys, including family income and the number of visits per season. Hourly temperature and daily attendance at the beach were also recorded. This it is possible to estimate willingness-to-pay as a function of temperature and congestion. The values in Fig. 1 reflect optimal congestion, calculated to be 400/acre.

There are other contingent valuation studies of the beach visits, including Bell and Leeworthy (1986) and NOAA (Leeworthy et al. 1989, 1991a,b, 1993, 1994). Some of these studies have problems, in terms of being able to determine the value of a beach visit. For instance, Bell and Leeworthy (1986) asked about the willingness-to-pay for an annual pass for all Florida beaches, which makes valuing an individual visit problematic.

### *Travel Cost*

Travel cost methods are some of the most widely used methods for valuing recreation opportunities. One of the earliest studies of beach values was done by Moncur (1975), closely following the classic travel cost approach. He focused on recreation on the island of Oahu, Hawaii, by local residents.

Moncur's approach was to conduct a mail survey (in 1972) of a sample of the Oahu population. Although his sample size was large (several thousand), his response rate was modest (31%). Using a zip code to identify each respondent's location he calculated the travel distance and travel cost to each beach for each respondent. Unfortunately, he did not provide much information on exactly how travel costs were computed.

Moncur estimated a model that specified the per person visitation rate as a function of the travel cost to each of 11 beach areas. He then calculated a population demand function for each beach and measured the surplus associated with each beach, holding the price of other beaches constant. Moncur was then able to calculate the surplus per person-beach-day for nine of the beaches examined. Those figures are on the

order of \$1/beach-day (1972 dollars) and are given in Fig. 1. Significantly, this is one of the few studies that looked at the cost of visiting substitute beaches when calculating the value of a specific beach.

A more complex model, involving choice among beach alternatives, was conducted by Bockstael et al. (1988) for the Chesapeake Bay. The authors surveyed a large number of visitors to 12 beaches during the summer of 1984. They then undertook two travel cost analyses of beach use. The authors used two models to estimate beach demand: a varying parameters model and a discrete choice nested multinomial logit model. According to the authors, neither was perfect for the application. The varying parameters model assumed each visitor used each of the 12 beaches during the season. The discrete choice model has a number of well-known problems, including the difficulty in representing demand for multiple trips to the same site.

For the varying parameters approach, Bockstael et al. specified a model in which the number of trips to a specific beach for a specific household depends on (1) out-of-pocket travel expenses (mileage and admission fees); (2) trip time; (3) trip expenses and time for a single substitute beach; and (4) ownership of a boat, recreational vehicle, or pool. Thus, the authors explicitly took into account substitute recreation opportunities. It appears that the specification used yielded estimates of a household demand function rather than a single user's demand.

The demand function the authors specified is linear, and consumer's surplus per trip can be calculated for the mean number of trips from the results they reported. Performing this calculation yields a household consumer surplus of \$4.70–\$38.50 (1984 dollars) for the six beaches with significant own price coefficients. The authors did not report average household size. Assuming an average household size of 3.78, the per person value of a beach visit ranges from \$1.24 to \$10.19, and values for five of the six beaches are between \$1.24 and \$3.04. The average value over the six beaches is \$3.23. Note that results for one beach are much higher than for the other five. This beach also had the highest cost of substituting to another beach, with travel time of over 1 h. This isolation (i.e., lack of cheap substitutes) could explain the high estimated value.

Other travel cost studies include Bell and Leeworthy (1986), Leeworthy et al. (1989, 1991a,b, 1993, 1994), and McConnell (1992). The study by Bell and Leeworthy (1986) focused on travel expenditures rather than travel costs, which makes the results difficult to interpret.

## Summary of Empirical Studies

What can be learned from this review of empirical studies? Turning to Fig. 1, the CV studies are remarkably consistent in the values they report for a beach-day. Despite variability in the type of CV question posed, all studies yield values of a beach-day from under \$1 to almost \$6, with the preponderance of values between \$1 and \$4/day. The two studies that provide for seasonal or temperature variation indicate that values do vary substantially by season.

However, most of the CV studies are relatively primitive by today's standards; few reflect the recommendations of the NOAA panel. The CV questions were often open-ended and were rarely posed as realistic decisions trading off some expenditure with the provision of a good. Of the CV studies, three seemed to be the best, although not without problems: Binkley and Hanemann, McConnell (Rhode Island), and the NOAA studies.

Similar to the CV studies, the travel cost studies also vary in quality. Typically, travel costs are imprecisely or incorrectly computed, demand equations are improperly specified, or substitutes are omitted. Of the travel cost studies, two appeared

to be the best, although again not without problems: Moncur and Bockstael et al.

The travel cost/travel expenditure studies have a wider range of values than the CV studies, in part because of the range of choice researchers have in analyzing the data (e.g., in functional form for demand and in computing travel cost). Of the two travel cost studies that seemed most carefully done, one (Moncur) generates values consistent with the CV studies, \$1–\$4/day. The other (Bockstael et al.) finds that values for five of the six beaches considered have values of \$1–\$4/day as well, consistent with the CV numbers. One of their beaches yielded a value of \$12.47, but this probably results from its isolation and lack of inexpensive substitutes. All of the other travel cost studies, excluding the problematic ones mentioned above, obtained values of \$1–\$3/day.

Although none of the studies is perfect, the bulk of the existing literature places the value of a saltwater beach-day, independent of season, in the range of \$1–\$4. Some studies place the value as high as \$12, but these appear to suffer from significant flaws. Also, these values apply to day use, not overnight tourist use.

## CONCLUSIONS

This paper reviewed some of the problems and methods associated with estimating the damage from lost beach recreation due to an environmental accident. The present study focused on estimating lost attendance and on transferring the value of a lost beach-day from other studies. Clearly, the option of conducting one's own study of the value of beach recreation for the beach affected by the environmental accident should also be considered.

One of the more important conclusions reached is that life-guard counts of beach visits may be inaccurate, with over-reporting by as much as a factor of almost 5 on a busy day. Aerial photos, combined with on the ground surveys of trip duration, can be used to provide defensible estimates of visitation.

The literature on valuing saltwater beach recreation places the value of a beach-day in the \$1–\$4 range (1990 dollars). There is, however, considerable room for improvement in our understanding of these values. Most of the CV studies of beach recreation are now fairly old and generally did not use methods that are up to the present state of the art. Some of the travel cost studies have shown the importance of including visit-specific or site-specific attributes, such as crowding, temperature, and season. Most travel cost and CV studies have ignored such considerations, however, in their design. The travel cost literature on beach recreation is often very casual about how travel cost is actually computed, sometimes to the point of ignoring time costs. Travel cost and CV studies often fail to incorporate opportunities to visit substitute sites in the study design.

Finally, none of the studies completed to date shed light on the potential for substituting visits over time (i.e., on the loss the recreationist experiences when a trip is delayed, but not eliminated entirely). This is, arguably, a very important gap in our knowledge with regard to assessing the damages from temporary beach closures.

## APPENDIX I. ESTIMATING OPEN ACCESS BEACH VISITS USING AERIAL PHOTOS AND SURVEYS

In the text, the problem of estimating the number of beach visits is discussed. The problem with relying exclusively on aerial photos taken at different points in time is that they give the number of people, not the number of distinct beach visits—it is not known how long people are at the beach. Thus the aerial photos can be supplemented with an on-site survey to

determine visit duration. Unfortunately, such an on-site survey will tend to oversample individuals who spend more time at the beach.

To illustrate the procedure, the present study's estimates of beach visitation at Newport Beach and Huntington City Beach over several days in the spring of 1995 are discussed below. Because aerial photographs are expensive, the analysis was carried out for only 5 days, 3 weekend days, and 2 weekdays, and the results from 2 days are presented in what follows. The procedure is divided into two parts: (1) Establishing the number of people on the beach at each time during a day; and (2) converting the estimated time profile of this stock of visitors to an estimate of visits. The first task is accomplished with aerial photographs. The second is accomplished by estimating average visit duration with data from a survey of arrival and departure times.

### Number of People on Beach

A major component of computing the actual attendance is an estimate of the number of people physically on the beach, bikepath, pier, parking area, water, and playgrounds at any point in time during a day:  $B(t)$ . The approach here was to take aerial photos at three times during the day, 11 a.m., 1:30 p.m., and 4 p.m. for the entire beach in question. Zero attendance was assumed at 6 a.m. (before sunrise), and visual counts of attendance at several other points in the early morning, were done. Manual night counts of attendance were also conducted for times after 6:00 p.m.

It was not exactly known when the peak beach attendance occurred during the day. The counts from the 1:30 p.m. photos were higher than the 11 a.m. or 4 p.m. photos, suggesting the peak occurred close to 1:30 p.m. It was assumed that  $B(t)$  was constant at the 1:30 value between 12:30 p.m. and 2:30 p.m. Linear interpolation was used for other times during the day to produce an estimate of  $B(t)$  for all  $t$  between 6 a.m. and 6 p.m. The last aerial photos were taken at approximately 4 p.m. The night counts allowed us to estimate beach attendance at 6 p.m.

### Duration of Beach Visits

Having established the time profile of the stock of visitors, an estimate of the duration of beach visits was needed in order to compute the number of visits. To compute duration, it is necessary to survey visitors. For an open access beach (with no entrances), sampling is difficult. One approach is for surveyors to randomly intercept individuals on the beach, asking their arrival time, expected departure time, and expectations about temporarily leaving the beach during their visit. From this, it is straightforward to compute the duration of their beach visit. However, the goal is to estimate the average visit duration over the population of beach visitors, and this sampling procedure tends to oversample visitors who make longer visits. For any sampling rate, a visitor who stays at the beach all day is far more likely to be surveyed than someone who is only there 20 min. Both types of visits count equally as "visits" for the purpose of estimating lost recreation value.

To correct for oversampling of long duration trips, each observation in the sample must be weighted by the probability of being sampled (Cox 1968). For the  $i$ th member of the sample, let  $a_i$  denote the arrival time,  $x_i$  the gross duration of the visit (including time spent away from the beach), and  $r_i$  the time spent away from the beach in restaurants and shops. The net duration of  $i$ 's visit,  $m_i$ , is simply  $x_i - r_i$ . Furthermore, let  $S(t)$  be the sample rate (people per hour) at time  $t$  and recall that  $B(t)$  is the number of people on the beach at time  $t$ . Define the sampling proportion as the ratio of these two,  $s(t) = S(t)/B(t)$ , the fraction of people on the beach sampled per hour at time  $t$ .

Given that a respondent is on the beach, the probability,  $\pi_i$ , that visitor  $i$  will be sampled is proportional to the fraction of beach visitors sampled during  $i$ 's visit:

$$\pi_i \propto \int_{a_i}^{a_i+x_i} s(t) dt \equiv \delta_i \quad (1)$$

Eq. (1) is simple to interpret. Note first that the probability that  $i$  is sampled depends on the amount of time  $i$  actually spends on the beach and on the sampling rate during  $i$ 's visit to the beach area. If  $i$  spent 4 h in the beach area, with 2 h in shops and restaurants, the probability of being sampled would depend only on time actually spent on the beach. Suppose an individual is at the beach for 4 h and suppose also that the sampling rate is constant at 1%/h over that period, which would be true if the number of people on the beach is constant and the number of people sampled per hour is constant. If one continually samples 1% of the people on the beach every hour, then the integral in (1) is simply the duration of the visit times the sampling rate. In this case (constant sampling rate) the probability that  $i$  is sampled is proportional to the duration of  $i$ 's visit. If the visitor spends 1 h of a 4-h visit off the beach at a restaurant, then this probability must be adjusted by the fraction of time the visitor is on the beach:  $(4 - 1)/4 = 0.75$ . Basically, the longer the visitor is in the beach area, the greater the likelihood of being sampled; the more time spent in a restaurant, the smaller the likelihood of being sampled.

This is a problem in sampling theory, where the sample is not random. The goal is to determine the mean duration of the entire population of beach visits. Let  $f(x)$  be the unknown population density of visit durations  $x$  and  $g(x)$  the known sampling distribution. One seeks to estimate the mean visit duration based on the population density, which is denoted by  $\mu$ . Utilizing the fact that the probability of being sampled is directly proportional to visit duration and inversely proportional to the number of visitors on the beach, as discussed in the context of (1), this implies (Cox 1968) that

$$g(x) = [\delta(x)/\Delta]f(x) \quad (2)$$

where  $\Delta$  = constant of proportionality that makes  $g$  integrate to 1; and  $\delta(x)$  = weight associated with a visit of duration  $x$ , developed for the discrete case in (1). Thus  $1/\Delta$  is equal to the expectation of  $1/\delta(x)$  with respect to the sampling distribution  $g$ . Rearranging (2), multiplying both sides by  $x$ , and integrating, one obtains

$$E_g[x\Delta/\delta(x)] = E_f[x] \equiv \mu \quad (3)$$

where  $E_g$  and  $E_f$  = expectations with respect to the distributions  $g$  and  $f$ , respectively. Unbiased estimates of  $\mu$  and  $\Delta$ ,  $\hat{\mu}$  and  $\hat{\Delta}$ , can be obtained from a sample of size  $N$

$$1/\hat{\Delta} = (1/N) \sum_i (1/\delta_i) \quad (4)$$

$$\hat{\mu} = (1/N) \sum_i (\hat{\Delta}/\delta_i)m_i \quad (5)$$

To implement this procedure the sampling rate was calculated on an hourly basis for each beach. For example, for Newport Beach during the period 10 a.m. to 11 a.m., the number of surveys executed during that hour was divided by the average number of people on the beach during the hour. This sampling rate was considered to be constant over the hour when calculating  $\delta$  in (1) for surveys completed during that hour.

### Estimating Visitation

Given an estimate of the average duration of a beach visit  $m$  and the time profile of the number of people on the beach

at any given time during the day, it is straightforward to compute the number of distinct beach visits. The integral under  $B(t)$  from 6 a.m. to 6 p.m.,  $\Omega_D$ , gives the number of person-hours spent on the beach during the day. The estimated number of daytime beach visits is simply

$$V_D = \Omega_D/m \quad (6)$$

This is, of course, only an estimate of day visits. To be complete, one should spot check night attendance.

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