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Valuing Coastal Beaches and Closures Using Benefit Transfer: An Application to Barnstable, Massachusetts

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Valuing Coastal Beaches and Closures Using Benefit Transfer: An Application to Barnstable, Massachusetts

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1. INTRODUCTION

Beaches and coastal areas provide important social and economic value for coastal communities and visitors. Beachgoing is particularly important, with approximately 59 million people visiting saltwater beaches each year in the United States (U.S. Census Bureau 2012). Given the considerable use of coastal areas for recreation, beach closures can lead to significant economic and social losses to coastal communities and their surrounding regions.

Beach closures and swimming advisories can happen for a number of reasons including bacterial contamination, harmful algal blooms, wave conditions (high surf and rip currents), as well as the less common shark sightings, hurricane warnings, or oil spills. While a closure prohibits all uses of a beach, a swimming advisory prohibits swimming activities but allows other shore-based activities to occur. Swimming advisories are also known as contamination advisories when they result from exceeding bacterial concentrations. We generalize the term “beach closure” to refer to full closures, swimming advisories, and contamination advisories.

Many beaches in the United States are monitored for bacteria to comply with requirements outlined in the Clean Water Act and various state regulations. Exceeding bacterial concentration thresholds requires a beach to be closed for swimming for a specified time after testing. In the United States, bacterial contamination advisories are the most common reason for beach closures. Figure 1 provides context on the significance and frequency of closures in the United States and geographic regions of interest in this article. In 2016, there were about 5,800 monitored coastal beaches in the United States (see Figure 1). For those beaches, there were almost 43,000 closure days at 1,625 beaches in their respective monitoring seasons because of bacterial exceedances (U.S. EPA 2016). A closer look at New England shows that there were 532 closure days at 119 of the 667 beaches during the monitoring season. While not as frequently closed as many other places in New England and the rest of the United States, Cape Cod also had closures of some of its beaches (57 closure days at 13 of the total 194 monitored beaches).

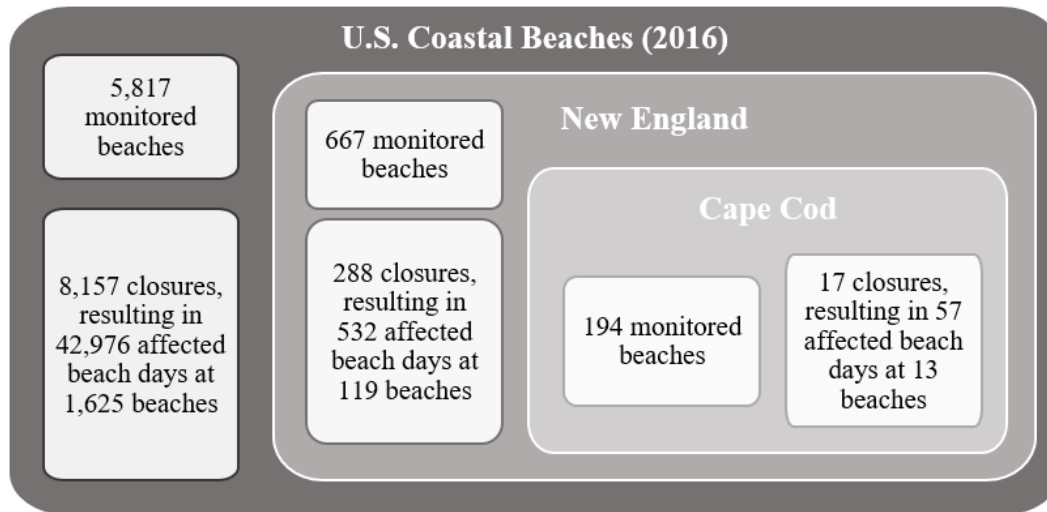


Figure 1. Monitored coastal beaches and their related closures in 2016. This figure includes the total number of monitored beaches and closures for each geographic area (the entire United States, New England, and Cape Cod). Closures due to bacteria may be determined through monitoring or based on models and may last for one or more days.

Source: U.S. EPA BEACON database (U.S.EPA 2017).

Given the significance of coastal recreation in the United States, it is important to understand not only how degraded water quality affects the use of coastal areas for recreation, but also to understand the economic consequences of these effects. This information can help policy makers and managers understand the benefits of their beaches as well as the costs to their communities from beach closures. Understanding the economic costs resulting from closures can contribute to policy evaluation of management options that will affect coastal beaches.

We conducted a meta-analysis of existing studies providing consumer surplus values per day because we were unable to find any studies directly relevant to our benefit transfer needs. Some existing studies value coastal recreation as a function of water quality (Opaluch et al. 1999, Murray et al. 2001, Lew and Larson 2005, Hilger and Hanemann 2008, Parsons et al. 2009, Awondo et al. 2011), but the results are not appropriate to our application in New England, for various reasons. Opaluch et al. (1999) can be used to estimate the change in non-market value, willingness to pay (WTP) per day, resulting from a change in various water quality parameters. However, it is an older study, using methods that are no longer state-of-the-art. Others, such as Hilger and Hanemann (2008), provide estimates of marginal WTP for specified changes in water quality, but these estimates are not

useful to determine the lost value of a closure event. Several studies focus specifically on beach closures or advisories related to water quality, but do not present the results in a form that is useful for our purposes (Lew and Larson 2005, Murray et al. 2001, Parsons et al. 2009, Awondo et al. 2011). This is either because there is not enough information provided to be used for benefit transfer, or because WTP estimates are presented for study-specific changes that cannot be used to estimate the value per day for a beach with a closure in a different location.

There are a number of studies that value beachgoing in various areas in the United States, including New England (see Table 1). We used these studies in a meta-regression for a benefit transfer to value a single beach visit. An objective of our work is to develop methods that can be transferred to other locations and translate values per day for a beach visit to lost values from a beach closure. Rosenberger and Loomis (2000, 2001) conducted meta-analyses that include beach and swimming values; however, they did not account for variations across beaches (particularly related to water quality), which we do in this study. We combined the meta-analysis with a panel regression model using readily-available daily beach visitation data and bacteria closure data to predict total beach visits on different days during the summer season. We present in this paper a benefit transfer approach to estimating the economic value of public beaches and the lost value due to beach closures. While we focus on Barnstable, Massachusetts on Cape Cod, the models and methods are transferable to other locations and useful for policy purposes.

Other researchers have conducted work complementary to ours. Kreitler et al. (2013) estimated a visitation model for Washington State Parks located on Puget Sound. They examined the relationship between mean bacteria (*Enterococcus*) counts and monthly visitation to beaches to show that poor water quality negatively affects visits to Puget Sound. Their approach used aggregate visitation data for parks, and thus is useful for predicting total visits over the beach season, but not visits on any particular day. Our approach, in contrast, focuses on daily visitation, which makes it more relevant to predictions of changes for specific days during the season that are affected by a closure event. Additionally, because visitation is highly variable across the season, understanding these changes makes local estimates more precise. We also go one step further by applying the predicted visitation to a benefit transfer to value those days.

While our work does not attempt to evaluate whether monitoring levels are effective, Rabinovici et al. (2004) conducted a similarly practical approach using

existing data and a benefit transfer. Specifically, they used existing visitation data and a benefit transfer to evaluate the economic losses from beach closures based on imperfect monitoring data and management closure decisions. They used a risk assessment framework to evaluate the potential losses stemming from both the value of a swimming day and the value of potential health risks. They focus on the risks to swimmers under different probabilities of contamination and different policies related to closures to estimate benefits and costs from imprecise predictions of harm. Using methods similar to both studies (Kreitler et al. 2013 and Rabinovici et al. 2004), this article provides information relevant to town and regional water quality efforts, as well as a practical and transferable method for quantifying the scale and value of threats posed by degraded water quality in coastal communities. To explain this approach, we used a town on Cape Cod, Massachusetts as a case study.

1.1 Study Area

Cape Cod, Massachusetts (Barnstable County; “the Cape”) has 560 miles of coastline and more than 194 public saltwater beaches. The Cape’s economy is largely driven by a seasonal influx of visitors and second homeowners. The Cape Cod Commission, the Cape’s regional planning body, estimated that roughly five million people visit Cape Cod each year, with about 65 percent of those visits occurring during the summer months (Cape Cod Commission 2015). More than 37 percent of the homes on Cape Cod are seasonal-use homes; this is the seventh highest percentage for all counties in the United States (Cape Cod Commission 2015, U.S. EDA 2015). The Cape’s population more than doubles during the summer months (USGS 2016). Due to this highly variable population, the infrastructure and economy of Cape Cod have developed around its tourism industry and seasonal homeowners.

The communities on Cape Cod benefit from recreational areas through beach fees, occupancy taxes, and the many associated amenities. Given the regional dependence upon water-based tourism, beach closures can result in large economic losses to these communities. In 2016, there were 17 closures at 13 beaches, resulting in 57 affected beach days due to an exceedance in bacterial concentrations (see Figure 1). While the rate of closures is low on Cape Cod relative to the rest of New England and other parts of the country, the area’s dependence on coastal recreation is high, making the incidence of closures important to the local

communities. The Barnstable County Department of Health tests beaches weekly for *Enterococcus* as an indicator of bacterial contamination from Memorial Day weekend through Labor Day weekend. The primary cause of bacterial contamination resulting in beach closures on the Cape is stormwater runoff (BCDHE n.d.).

The town of Barnstable, Massachusetts is a municipality that serves as the central hub of Cape Cod and houses many of the Barnstable County agencies and organizations. It is the largest town on the Cape and greatly contributes to total visitation to the area. The coastlines of Barnstable include both Cape Cod Bay to the north and Nantucket Sound to the south, providing a number of beaches and other points of public access to the water with a range of water quality.

We selected four beaches in the town of Barnstable because they have the most extensive daily visitation records: Craigville Beach, Kalmus Beach, Keyes Memorial Beach, and Veteran's Park Beach (Figure 2). These four beaches require daily parking fees and are accessible to both residents and out-of-town visitors. Parking attendants are responsible for keeping track of the total number of daily visitor passes sold, as well as recording any cars with town permits that park at the beach each day. This provides useful data on beach use by the type of visitor. Visitation data (in the form of car counts) used in this study included days on which both daily parking passes and town permits were recorded. Daily parking fees are collected during the summer season (Memorial Day weekend to Labor Day weekend) and from the hours of 9:00 AM to 3:45 PM each day.

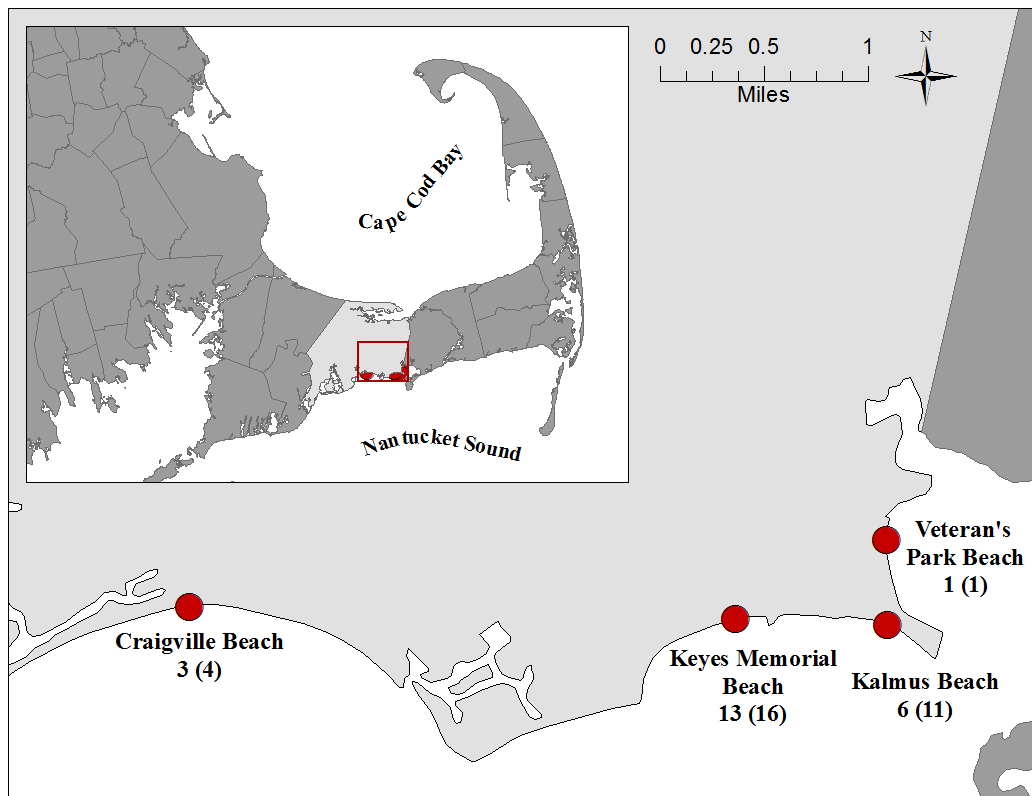


Figure 2. Beaches in Barnstable, MA with sufficient available visitation records. Numbers below beach names indicate total closures posted between 2000-2016 and affected beach days (in parentheses).

As a limitation to the data, we recognize that these daily car counts do not incorporate visitation from beachgoers who walk or bike to the beach or visit the beach during the off-hours (before 9 AM or after 3:45 PM). Therefore, our estimates of total visitors are likely to be an underestimate of beachgoers because there is some visitation that we cannot capture. For this study, we used visitation records collected in the 2012-2015 fiscal years (July 1, 2011 to June 31, 2016). These four beaches were also monitored weekly during the summer season for bacteria (*Enterococcus*) by the Barnstable County Department of Health. Based on available closure data from 2000-2016, all four beaches experienced exceedances in bacterial concentrations resulting in closures (see Figure 2 for the number of closures posted at each of the sites).

2. METHODS

The net economic value of a beach visit is the sum of its market and non-market values, subtracting the cost to society of providing the amenities. Estimating the direct market values, money spent by visitors in the local economy and town fee revenue, is relatively straightforward, provided relevant expenditure surveys and town revenue data exist. These market economic values can directly and indirectly impact the local economy through use fees and other travel expenditures and incidental purchases made by visitors to the area. Indirect market impacts can increase the total magnitude of market impacts, but estimating indirect market economic impacts requires the use of input-output models (Rickman and Schwer 1995, Ambargis and Mead 2012). We include town fee revenue, but do not address other direct or indirect market impact measures in this work.

Beyond market expenditures, recreation provides non-market values to visitors. As a measure of non-market value, consumer surplus reflects the benefits received by visitors above and beyond the money they spend to be able to enjoy the beach. It is the difference between what they paid to enjoy the beach and the maximum they would have been willing to pay for the experience, hence the term net willingness to pay (WTP) (Lipton et al. 1995, Pendleton 2008). Quantifying the consumer surplus, which may account for a large percentage of the economic value of a beach day (especially when it is provided as a public resource¹), is more complex than measuring direct market values and requires more involved methods.

We divided the process we used in this study into multiple steps (see Figure 3). In Step 1, we used existing studies in a meta-analysis to estimate appropriate benefit transfer values of consumer surplus per beach visit for Barnstable. The studies we include in the model are for beaches across the United States, allowing the meta-regression model to be more broadly applicable to other beaches and for values to be adjusted based on appropriate site attributes.

¹ A public beach is technically a quasi-public good. Access is provided as a public resource with the entrance fees designed to cover maintenance expenses, not necessarily to turn a profit.

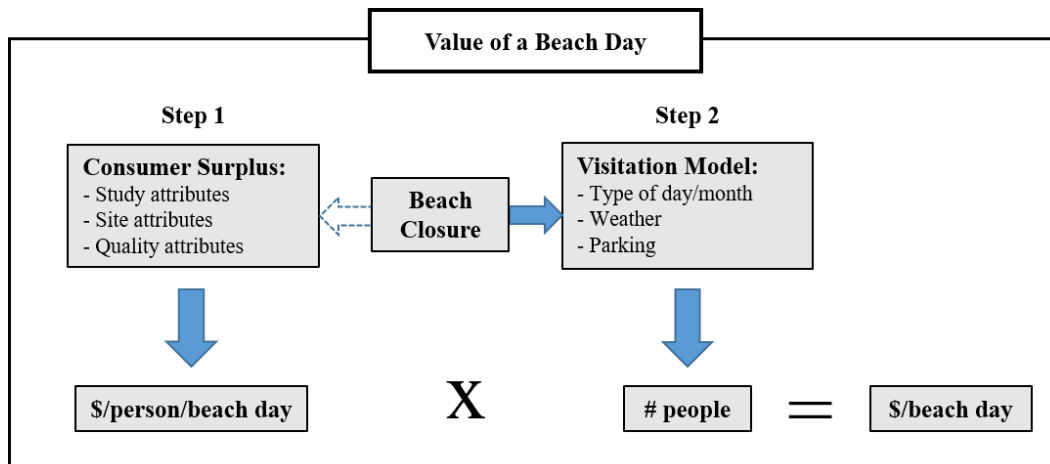


Figure 3. Relationship between models and data used in analysis for valuing a beach day.

In Step 2 (see Figure 3), we estimated a visitation model based on car counts at beaches where parking fees were collected, which we then translated to visitor counts. Our visitation model can be applied to other beaches or days where counts are not conducted, because it includes other factors—parking, day of the week, season, and weather—that determine the number of visits on a given day. Combining visitation data and beach closure data allows us to estimate lost visits when a closure occurs. This is indicated in Figure 3 by the solid arrow between beach closure and the visitation model. Our visitation model aims to estimate beach visits using readily-available information. It is currently calibrated for the town of Barnstable but is potentially transferable to other locations.

We combined the outcomes of these two steps, presented in the Results section, to demonstrate practical ways in which these models can be applied to estimate the aggregate value of a beach for a given type of day (weekday/weekend in a given month); the value for a beach for a season; and damages, in terms of lost consumer surplus and town fee revenue², incurred from a beach closure on a given type of day. While not included in this study, beach closures may also directly impact the amount a person would be willing to pay for the beach experience given the

² Since there are undoubtedly other market expenditures related to a beach visit, such as gas, food, and beach toys, and since we do not attempt to estimate indirect market impacts, our estimates of market impacts are conservative. Future coastal recreation expenditure surveys could inform this estimate.

swimming restrictions. This is indicated by the dotted arrow in Figure 3 and is discussed further in the discussion section.

2.1 Step 1: Estimating Consumer Surplus (Net WTP) for a Benefit Transfer

We conducted a meta-regression of consumer surplus per day to use in a benefit transfer, following generally accepted practices (Rosenberger and Loomis 2001, Bateman and Jones 2003, Bergstrom and Taylor 2006, Nelson and Kennedy 2009, Stanley et al. 2013, Johnston et al. 2015). Benefit transfer approaches apply values from existing studies to a new policy application, often attempting to adjust for variations between the original study context(s) and the new policy context (Ready and Navrud 2003, Iovanna and Griffiths 2006, Wilson and Hoehn 2006, Johnston et al. 2015, Richardson et al. 2015).

To identify relevant studies, we selected 25 studies of beach use and swimming from the Recreation Use Values Database (RUVD), where consumer surplus values are presented as value per day in 2016 dollars (Rosenberger 2016). We conducted an additional literature search using other valuation databases and a literature review on beach valuation studies associated with water quality (NOEP 2017). Because the RUVD was recently updated, we did not find any additional studies usable for our application from outside the database. While there were a few relevant studies, they did not provide adequate data and information to be included in our meta-regression.

The 25 studies provided 98 observations, with 15 studies providing multiple consumer surplus estimates. The included studies were conducted between 1960 and 2011; 22 used revealed preference methods and three used either stated preference or a combination of revealed and stated preference methods. Five of the studies were focused on multiple regions or a national scale, while seven were specific to New England, two were in the Midwest, six were in the South, and eight were in the Western region of the United States. These studies included both freshwater and saltwater beaches. Table 1 shows the list of included studies with summary information. There are a multitude of activities that visitors to a beach might partake in, including specialized activities that may have higher per-day consumer surplus values than general beachgoing, such as windsurfing or surfing (Nelsen et al. 2007). Therefore, our estimates may be a conservative estimate of consumer surplus for visitors to the beaches in this study.

Table 1. Studies Included in Meta-Analysis.

Author(s) and year	Number of obs.	State(s)	Type of Water	Activity	Net WTP (in 2016\$)
Bergstrom & Cordell 1991	1	National (USA)	FW/SW	Swimming	\$31.15
Bin et al. 2005	14	NC	SW	Beach use	\$14.46 - \$103.31
Johnston et al. 2002	1	NY	SW	Swimming	\$13.46
Kalter & Gosse 1969	1	NY	SW	Swimming	\$52.60
King 2001	1	CA	SW	Beach use	\$41.32
Kline & Swallow 1998	2	MA	SW	Beach use	\$4.79 - \$6.55
Landry & Liu 2009	1	NC	SW	Beach use	\$55.84
Landry & McConnell 2007	4	GA	SW	Beach use	\$9.53 - \$16.64
Leeworthy & Wiley 1991	8	NJ	SW	Beach use	\$35.10 - \$149.46
Leeworthy & Wiley 1993	12	CA	SW	Beach use	\$15.72 - \$204.55
Leeworthy & Wiley 1994	12	FL	SW	Beach use	\$27.24 - \$305.67
Leggett et al. 2003	1	TX	SW	Swimming	\$11.31
Lew & Larson 2005	1	CA	SW	Beach use	\$38.20
Lew & Larson 2008	2	CA	SW	Beach use	\$29.84 - \$30.98
McCollum et al. 1990	4	AR,FL,GA, MS,NC,SC, TN,IN,MI,NH, OH,WI,WV, OR,WA,CA	FW/SW	Swimming	\$18.80 - \$48.31
McConnell & Industrial Econ, Inc. 1986	2	MA	SW	Beach use	\$13.83 - \$16.72
McKean et al. 2005	1	WA	FW	Swimming	\$27.08
Moncur 1975	8	HI	SW	Beach use	\$2.00 - \$7.83
Parsons et al. 2013	2	DE	SW	Beach use	\$35.37 - \$39.42
Sohngen et al. 1999	4	OH	FW	Beach use	\$29.13 - \$39.62
Sutherland 1982	1	MT	FW	Swimming	\$12.64
Ward 1982	4	NM	FW	Swimming	\$9.37 - \$78.06
Whitehead et al. 2008	1	NC	SW	Beach use	\$32.47
Whitehead et al. 2010	4	NC	SW	Beach use	\$134.52 - \$392.13
Yeh et al. 2006	6	OH	FW	Beach use	\$1.83 - \$9.60
Total	98			Mean	\$63.07
				Sample size weighted mean	\$45.28
				Median	\$31.16

Note: Types of water are abbreviated as FW for freshwater and SW for saltwater.

The standard practice for meta-regressions of economic values is to include categories of variables that can influence study values, including study characteristics, location characteristics, and characteristics of the population (Bergstrom and Taylor 2006, Shrestha et al. 2007, Nelson and Kennedy 2009, Stanley et al. 2013). We began with a set of variables available from the RUVD to represent these categories and added location-specific variables for the study beaches using other sources. The additional characteristics we gathered were median county income, length of beach(es), and percent of beach season closed in the last five years (2011-2015; U.S. Census Bureau 2017, U.S. EPA 2016)³. We initially added median county income for the location of the study beaches because the RUVD did not contain sample income for all studies. However, we found median county income was not significant in our models, and we do not present models including the income variable in our model results. We added beach length and history of closures to contextualize the model for our application by proxying water quality and site quality.

The meta-regression was formulated as:

$$Y = \beta_0 + \beta_1\mathbf{S} + \beta_2\mathbf{P} + \beta_3\mathbf{Q}$$

Equation 1.

Where,

Y - log value per person per day (in 2016\$)

β_0 - intercept

\mathbf{S} - vector of dummy variables for study characteristics (i.e., type of water, region)

\mathbf{P} - vector of dummy variables for characteristics of people (i.e., type of visitor, length of trip)

\mathbf{Q} - vector of dummy variables for site quality characteristics (i.e., length of beach, water quality)

We began by calculating the mean of the consumer surplus values (\$63.07) and mean consumer surplus values weighted by the original study sample size (\$45.28), as recommended by Nelson and Kennedy (2009). Next, using ordinary least squares, we specified a series of regressions by first controlling for study

³ The BEACON database provided by the U.S. EPA is only available for coastal bathing beaches and beaches on the Great Lakes. We were unable to collect beach attributes (length and % season closed) for freshwater studies.

attributes and regional variables in the RUVI (Table 2, model 1), followed by adding variables describing the population of beneficiaries and type of beach visit valued in the studies (model 2). Lastly, we added our quality variables using dummy and interaction terms to control for beaches for which we do not have length or closure information (models 3 and 3c). Our preferred model (Table 2, model 3) minimizes the Akaike Information Criteria (AIC), has the highest R-squared value, and includes the control variables for beach attributes.

Table 2. Meta-Analysis Regressions

Regression Model	Dependent variable: Log \$CS			
	1	2	3	3c
Saltwater beach	0.885** (0.304)	0.668 (0.343)	1.128** (0.338)	1.128 (0.754)
Northeast region	0.391 (0.315)	-0.004 (0.312)	-0.733* (0.306)	-0.733 (0.378)
Daytrip (vs. overnight)		0.946** (0.290)	0.920** (0.251)	0.920* (0.394)
Resident (vs. nonresident)		-0.478 (0.253)	-0.593* (0.247)	-0.593* (0.280)
Length of beach (ft)			-0.008* (0.003)	-0.008 (0.004)
Closed in last 5 years (Y/N)			-0.772** (0.266)	-0.772** (0.284)
Constant	2.672** (0.262)	2.542** (0.264)	3.319** (0.286)	3.319** (0.298)
Observations	98	96	96	96
R ²	0.113	0.278	0.486	
Adjusted R ²	0.094	0.246	0.445	
Residual Std. Error	1.229 (df = 95)	1.132 (df = 91)	0.971 (df = 88)	0.971 (df = 88)
F Statistic	6.0** (df = 2; 95)	8.8** (df = 4; 91)	11.9** (df = 7; 88)	28.9** (df = 7; 88)
AIC		303.08	276.47	
Policy WTP	\$51.83	\$50.61	\$21.99	\$21.99

* p<0.05, ** p<0.01

Note: Standard errors reported in parentheses. Interaction terms for beach length and closure history included in the model, but removed from table (see Supplementary Materials). Regression model 3 is the preferred model with 3c representing the same attributes, but clustered by study. The F statistic for regression model 3c is approximated assuming the robust version of the variance covariance matrix with a Wald test.

Using this model, we estimated the consumer surplus of a beach visit for our study area as \$21.99 (with \$7.87 and \$61.44 as the lower and upper bounds of a 68% prediction interval), conditional on the variables for our policy application (see Supplementary Materials for details on how the policy-relevant WTP was calculated for each model). Model 3c corrects for heteroskedastic errors by clustering by study (see Supplementary Materials for details), resulting in the same coefficients as model 3 but with larger standard errors.

The meta-regressions show a larger consumer surplus per day for saltwater beaches than freshwater beaches, and lower values for studies in the Northeast⁴ as compared to other regions. Studies that valued day trips, as opposed to overnight trips or a combination of both, had larger values per day. Our interpretation is that this may be a result of splitting travel costs for beach days over many days in multi-day trip studies. Residents have lower per-day values than visitors, possibly reflecting their ability to visit the destination more often as well as the fact that living closer to the site results in lower travel costs, on which the valuation methods depend.

The inclusion of additional variables controlling for aspects of the study site (beach length and whether the beach had experienced closures) added to the overall fit of the model, resulting in a decrease in the AIC from regression model 2 to 3 (Table 2). Both site attribute variables were strongly significant and negative. The water quality proxy variable, using the five-year history of closures, captures the difference between pristine beaches and those that have been affected by pollution and closures. It also is likely to be correlated with other omitted, but relevant, site quality aspects of the surrounding area, such as nearby development. The length variable is used to proxy other aspects of beach quality, based on the assumption that beach length captures the scale of the resource and correlates with other amenities for visitors, such as bathrooms and concessions.

Our case study beaches in Barnstable were all closed for at least one day between 2011 and 2015 due to bacterial contamination (see Figure 2). As a result, the estimated net WTP for these beaches, presented above, is \$21.99 per day. However, if all other variables were held constant using values for the Barnstable beaches, the consumer surplus of a beach day in Barnstable with no closures in the

⁴ Because each US region was represented as a dummy variable, our regression model only includes the Northeast region for our purposes. However, to make the model applicable to other regions, we present the results for other regions in the Supplementary Materials.

last five years would be \$47.58 (see Supplementary Materials). Thus, the consumer surplus of a beach day with no closure history is more than double that of a beach that has had closures in the past. This comparison indicates the possibly significant gain in value when beaches are unaffected by poor water quality and maintain a “pristine” reputation.

2.2 Step 2: Beach Visitation Model

We needed beach visitation estimates to assess the number of people who would be impacted by beach closures. We modeled visits by combining daily parking counts with other factors that help explain variations in attendance, including weather, day of the week or point within a season, and physical differences in sites (Kreitler et al. 2013). We designed the resulting model to estimate visitation for uncounted days as well as for beaches without counts on a given day. When combined with estimates of value per day, the visitation model can be used to value a lost beach day while accounting for beach size, time of season, and other factors.

Since our count data of visitation for all four beaches are relatively large numbers (mean = 490, SD = 440), we used a log-linear regression model as opposed to a count data model. We selected a random effects model to account for time-invariant variables such as parking spaces, modeling differences across beaches based on this variable (see Supplementary Materials for details of the model selection and comparisons across panel specifications). We hypothesize the amount of parking is a good proxy for visitation because beaches with more parking available will likely have larger daily visits than those with fewer parking spaces. Parking is also likely to be correlated with other beach attributes, such as bathrooms or other facilities. Therefore, the marginal effect of the parking variable in our regression would include the effects of omitted, but correlated attributes of a beach.

The econometric specification is as follows:

$$Y_{it} = \beta_0 + \beta_1 P_i + \beta_2 W_t + \beta_3 M_t + \beta_4 D_t + \beta_5 H_t + \beta_6 C_{it} + u_i + e_{it}$$

Equation 2.

Where,

Y_{it} - log visits to beach i on day t

β_0 - intercept

P_i - number of parking spots at beach i

W_t - vector of daily weather conditions (temperature, precipitation, and rainy-day dummy variables) at Barnstable Municipal Airport

M_t - vector of month dummy variables

D_t - vector of day of the week dummy variables

H_t - vector of dummy variables for holiday weekends and all other weekends

C_{it} - vector of dummy variables for each day a beach had a closure posted between 2011-2015

u_i - between beach error term, the random effect

e_{it} - within beach error term

We fit the random effects model using maximum likelihood methods with the ‘lme4’ package in R (Bates et al. 2014). We used this model to simulate attendance at each of the beaches by type of day (weekend or weekday), month, and by whether it was a holiday weekend. We also included weather data to account for differences in attendance by weather conditions.

Using the visitation model (Table 3), we are able to make predictions about the estimated number of visits to each beach on a type of day within the season, and visits to a beach with a closure posted. The effect of parking spaces is highly significant and positive. Craigville Beach is the largest of the four beaches and has the most parking available, with 450 designated spaces. Kalmus Beach has 320 spaces, Keyes Memorial Beach has the smallest parking lot with 120 spaces, and Veteran’s Park Beach has 250 spaces.

Table 3. Random Effects Model

	<i>Dependent Variable:</i> Log Visits (as car counts)
Number of Parking Spaces	0.005** (0.001)
Temperature (°F)	0.053** (0.004)
Precipitation (in)	-0.332** (0.090)
Rain Dummy	-0.452** (0.047)
Wind speed (m/s)	-0.057** (0.013)
Holiday weekend	0.661** (0.085)
Weekend	0.347** (0.038)
Closure between 2011-2015 (Y/N)	-1.102** (0.334)
June	0.426** (0.121)
July	0.788** (0.119)
August	0.685** (0.119)
September	-0.057 (0.129)
Constant	-1.451** (0.447)
Observations	1,179

*p < 0.05, **p < 0.01

Note: Standard errors reported in parentheses. Dummy variables for each year (2011-2016) included in model but removed from table.

Using a log-linear specification implies the effects of the various regressors are non-linear and not additive, but multiplicative when changes in multiple explanatory variables are considered. When interpreting the results of a log-linear regression, a percent change in daily car counts (Y) resulting from a change in one of the explanatory variables, holding all others constant, is calculated as $100 \cdot (e^{\beta_i} - 1)$.⁵ Holiday weekends increased the visitation at beaches by 94 percent compared to the lowest points of use at the beginning of the summer season in May 2011. A

⁵ The usual rule of thumb approximation used in log-linear regressions with the coefficient value representing a one-unit change in a regressor leading to a $\beta\%$ change in Y only works when β is between -0.1 and 0.1.

closure resulted in 67 percent fewer predicted visits on a given day. Prediction ranges for given days and beaches can be found in the Supplementary Materials.⁶

2.3 Step 3: Application of the Benefit Transfer and Beach Visitation Model

2.3.1 Value of a Beach Day

As shown in Figure 3, the total value of a beach day is the product of the consumer surplus (\$/person/beach day) and the predicted number of visitors on that day (# people). This aggregate value of a beach day is presented for different types of days within the season.

2.3.2 Predicted Visitation for the Season

Taking into account weather conditions throughout the season, we simulated beach use from Memorial Day weekend to Labor Day weekend. We then applied the consumer surplus values to estimate a seasonal value of each beach.

2.3.3 Value Lost from a Beach Closure

While it might be assumed that the economic value of a beach day and the value of a lost beach day would be symmetric, they are not quite the same in our analysis. This is because the town has many fixed costs for beach management, including staff, facility maintenance, and other amenities. These fixed costs are offset by the daily parking fees charged to out-of-town visitors and the various beach stickers available for town residents. Assuming the town does not make a profit and just breaks even on beach parking fees in relation to the costs incurred to provide the services, the net economic value of a day without a closure (benefits less costs) would simply be the consumer surplus for the public⁷.

However, this amount is different than the net economic value lost due to a beach closure, which includes the lost consumer surplus as well as the lost revenue to the town. This revenue is money the town would have collected to cover costs

⁶ The data and code to model both the meta-regression of consumer surplus and predicted beach visitation can be found at https://github.com/USEPA/Recreation_Benefits.

⁷ While it is conceivable a town could run an accounting profit on its beach operations, it would contribute to many other municipal services that make a beach available, such as roads and emergency services.

and therefore is considered a loss (negative producer surplus). Therefore, a beach day affected by a closure is valued as a loss of consumer surplus plus lost parking revenue.

We estimate 67 percent fewer visits on a day with a closure, based on our visitation model. It is possible that some of these visits are substituted to other beaches in the town or substituted in time. By considering them lost altogether, we may be overstating the impact. However, given the level of congestion at Cape Cod's beaches and their limited capacity, it is possible that people may be unable to visit a substitute beach. It is also possible that when additional visitors visit substitute beaches, it may lower values at those locations due to congestion (Timmins and Murdock 2007). More complex modeling allowing for substitution and congestion is left to future data collection and work.

As mentioned earlier, beaches in Barnstable allow both residents with seasonal passes and out-of-town visitors who purchase a daily parking fee to access each of the four public beaches. Based on this differential in use data collected by the town, 51 percent of the cars that park are non-residents and purchase a daily pass to park for the day. For calculating lost parking revenue, resident passes were excluded because those individuals pay once in advance for a season and have the ability to go multiple times in a season. In 2016, for the town of Barnstable, it cost \$20 for a daily parking pass for out-of-town visitors. Assuming this is the only market expense for beach visitors, likely underrepresenting the total market impact, this \$20 is applied to 51 percent of the cars parking at the beach.

The resulting formula for the value lost from a beach closure is:

$$\$c = - \left[wtp * \Delta visits + \left(p * \frac{\Delta visits}{ppc} * \%nonresident \right) \right]$$

Equation 3.

Where,

$\$c$ – market plus non-market losses due to a beach closure

wtp – consumer surplus per person per visit from meta-regression

$\Delta visits$ – lost visits due to a beach closure (number of people)

p – parking fee per car

ppc – people per car

$\%nonresident$ - percent of visits (cars) that are non-residents of the town of Barnstable

3. RESULTS

3.1 Value of a Beach Day

Using the visitation regression model presented above (Table 3), we predicted daily summer visitation for different types of days within the season. Specifically, we broke each month down to explain predicted visitation for a weekend, weekday, and when relevant, a holiday weekend day for each of the four months (May-September). We predicted visitation using 2015 as the reference year because it is the most recent complete season we have available within our dataset. In the scenario analyses to predict visitation by type of day, we held weather constant to represent attendance on an “average” beach day. This means no rain, light wind, and 79° Fahrenheit.

Figure 4 (left Y axis) depicts the predicted beach attendance in terms of number of visitors, converted from cars to people by multiplying car counts by three (which the town of Barnstable uses when estimating visitation to their beaches; Patti Machado, Leisure Services Director for the Town of Barnstable’s Recreation Division, email to author, September 14, 2016). Ranges of visitation estimates are presented in the Supplementary Materials.

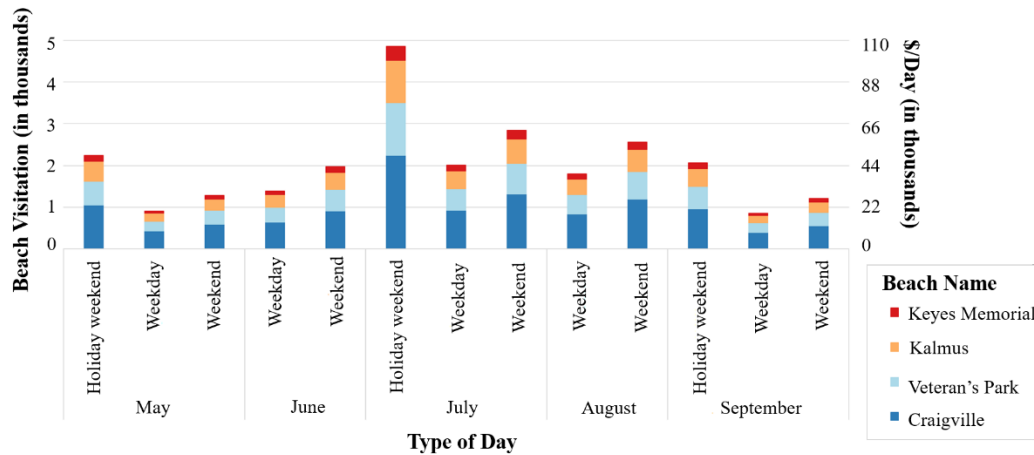


Figure 4. Beach visitation predictions (left Y axis) by type of day representative of 2015 and when holidays fall within that year. Fourth of July happened to be on a weekend in 2015, which explains the exceptionally high visitation. Holiday weekends represent the attendance and value of a single day within that weekend. Visitation is predicted using average weather conditions. Non-market value of a beach day (right Y axis) multiplies the visitation numbers by consumer surplus value of \$21.99/day (2016\$). Results can be found in tabular form in the Supplementary Material.

Using the calculated consumer surplus value appropriate to these Barnstable, MA beaches from the meta-regression results (\$21.99 in 2016\$; Table 2), we applied a dollar value per person to the predicted visitation (Figure 4, right Y axis). As discussed earlier, the estimated value of a beach for a particular day is based only on consumer surplus and does not include other market expenditures, since we assumed parking revenue just covers costs. Therefore, the estimates are conservative. Consumer surplus values for a beach day with average weather for the four studied beaches range from \$1,400 (low use, small beach) to \$50,000 (high use, large beach).

3.2 Predicted Visitation for the Season

Understanding the attendance for each beach given the type of day is useful to show variation within a season. However, to estimate total attendance at each beach for the whole summer season, other factors must be considered. Given the variability in weather conditions, we predicted a summer season by averaging results using four seasons of weather (2012-2015). The town of Barnstable starts collecting parking fees on Memorial Day weekend and stops by Labor Day weekend, and

these holidays can fall on different days each year. Therefore, a summer season for Barnstable can vary by a couple of weeks, but on average, there are 107 beach days that make up a summer season.

Using predicted visits within the four years, we calculated the average total visits for a single summer. This prediction process was simulated two thousand times, drawing from the distribution of coefficient estimates and random effects to account for uncertainty in our visitation model using the ‘merTools’ package in R (see Supplementary Materials for ranges and code; Knowles and Frederick 2016). Predicted visitation for the whole season, using these parameters, is displayed in Table 4. Using the logic previously mentioned, we estimated an aggregated net WTP (consumer surplus) value for each beach for the entire season. The seasonal value of each beach is estimated using both the consumer surplus fitted for the town of Barnstable from the meta-regression (\$21.99) and under a scenario where there were no beach closures in a five-year history (\$47.58). The results under the existing scenario (beaches with a closure history) predict a total consumer surplus value of almost \$4.3 million for the season for Barnstable’s four public beaches. In a “pristine” (no closures) condition, the total value increases to over \$9.2 million for the season.

Table 4. Total Beach Attendance and Consumer Surplus for the Bathing Season Based on Simulated Prediction Estimates.

Beach Name	Total Visitation	Season Value ^(a) (2016\$)	Season Value ^(b) (2016\$)
Craigville	90,354	\$1,986,884	\$4,299,043
Kalmus	40,505	\$890,705	\$1,927,228
Keyes Memorial	13,506	\$296,997	\$642,615
Veteran's Park	50,115	\$1,102,029	\$2,384,472
Total	194,481	\$4,276,637	\$9,253,406

Note: (a) Indicates value using a policy application of consumer surplus of \$21.99, the value of a beach with past closures. All four beaches had closures between 2011 and 2015. (b) Represents the value if all beaches were considered “pristine,” meaning no closure was posted from 2011 – 2015 due to bacterial contamination. This scenario uses the consumer surplus value of \$47.58 to estimates aggregated value for the season.

3.3 Value Lost from a Beach Closure

Economic losses as a result of beach closures by type of day are shown in Table 5. This is based on visitation estimates taken on an “average” beach day, described above. These losses include both consumer surplus and daily parking fee revenues, as described in the Methods section and shown in Equation 3. A breakdown of the value lost due to consumer surplus and parking revenue separately can be found in the Supplementary Materials. Losses range from around \$1,000 per day on a May weekday at Keyes Memorial Beach (the smallest beach during the slowest period), to over \$37,000 per day on the Fourth of July weekend at Craigville Beach (the largest beach during the busiest period).

Table 5. Value Lost Per Day Due to a Beach Closure, in 2016\$.

	Beach Name			
	Craigville	Kalmus	Keyes Memorial	Veteran's Park
May				
Memorial Day weekend	-17,481	-7,845	-2,588	-9,657
Weekday	-7,097	-3,170	-1,055	-3,967
Weekend	-10,056	-4,504	-1,480	-5,538
June				
Weekday	-10,847	-4,838	-1,608	-5,996
Weekend	-15,270	-6,858	-2,277	-8,501
July				
Fourth of July weekend	-37,534	-16,951	-5,591	-20,865
Weekday	-15,610	-6,945	-2,307	-8,592
Weekend	-22,060	-9,855	-3,275	-12,166
August				
Weekday	-13,999	-6,277	-2,085	-7,773
Weekend	-19,917	-8,870	-2,952	-10,978
September				
Labor Day weekend	-16,038	-7,184	-2,382	-8,919
Weekday	-6,685	-2,991	-9,985	-3,705
Weekend	-9,197	-4,257	-1,390	-5,350

Note: These values were calculated using 2015 visitation predictions. Holiday weekend estimates are presented as a single day within the weekend based on 2015 and when holidays happened to occur that year. See Supplementary Materials Table 5 for the breakdown of the lost value between consumer surplus and parking revenue.

A specific application of this model allows us to understand the impacts of a closure on a particular day. For example, on Wednesday, June 8, 2016, a closure was posted at Keyes Memorial Beach. Like many other days when closures were posted, visitation records were unavailable. Using our visitation model, we were able to estimate the value lost due to this single day closure. According to NOAA's National Centers for Environmental Information database (NOAA 2016), this particular Wednesday had no rain, a maximum temperature of 73 °F (cooler than average), and above average wind speed (5.9 m/s). With no closure posted, there would be an estimated 82 people visiting this small beach on a weekday in June with those weather conditions. However, because there was an advisory that day, the predicted visitation on an already low-use day decreases to an estimated 27 people. The value lost to Keyes Memorial Beach due to this beach closure can then be estimated as \$-450. While Keyes Memorial Beach is the smallest beach in this study and the weather was not ideal for a "beach day," this exercise draws attention to the varying impacts of a closure and the wide applicability of our benefit transfer approach.

4. DISCUSSION

The beaches of Barnstable, the largest town on Cape Cod, are a valuable public resource, and beach closures can result in significant losses to coastal communities. With the limited season and relative scarcity of places to access and enjoy the water, beaches with significant parking provide important social and economic value to society. At just the four beaches included in this study, there can be about 200,000 visits in total over the summer season between the hours of 9:00 AM and 3:45 PM. This sums to about \$4.3 million in non-market economic value to those people who visit Barnstable beaches, in addition to direct revenue from day-visitor parking of about \$650,000⁸. Considering this is only the value of four beaches within a single town on Cape Cod, which has almost 200 saltwater beaches across its 15 towns, including the Cape Cod National Seashore, the overall economic value of coastal recreation is notable.

⁸ The average visits in a season to all four beaches are based on prediction estimates from 4 years of data and corresponding weather conditions between 2012-2015. Barnstable, MA chooses not to collect parking fees early in the season on weekdays when visitation is low. Therefore, the direct revenue to the town, which does consider those days in the model, represents a slightly over-estimated value.

The loss due to a beach closure varies depending on when it occurs in the season and at which beach the closure occurs (see Table 5). We estimated that losses (consumer surplus and parking revenue) per day for a single beach in Barnstable range from around \$1,000 to over \$37,000 based on seasonal average weather conditions. According to the breakdown by type of day and beach (Figure 4), visitation is highest on the Fourth of July weekend, followed by other July weekends. The visitation model is also unique in that it allows prediction of lost visits on a specific closure day and then estimation of the aggregate lost value by that single closure event. As an example, Keyes Memorial Beach had an aggregate lost value of \$-450 for a weekday in June 2016 with less than ideal weather conditions. While available closure data was overlapping for a smaller beach at the beginning of the season, this approach could be done for a closure to a much larger beach on Cape Cod at a time when there is maximum visitation (such as the Fourth of July weekend). For example, as shown in Table 5, the calculated loss at Craigville Beach for the Fourth of July weekend is over \$37,000. A closure at a larger beach than those in our study would affect even more people and lead to a significant loss in value. Lastly, when the total lost value is broken down into lost consumer surplus and lost town revenue, the revenue collected by the town makes up only 12 percent of the value lost to society (see Supplementary Materials). Consumer surplus is the more significant portion of the economic value lost.

Given that non-market value is important in the economic value of a beach, a missing piece in this puzzle is the impact a beach closure would directly have on consumer surplus, assuming a person still chooses to go to the beach (dotted arrow in Figure 3). Based on available data, we used visitation records for days when a closure was posted to determine the percentage of visitors that would not go to the beach that day. This explains the connections between beach closures and visitation. However, we were unable to measure the connection between beach closures and consumer surplus in this study, other than the impact of *past* closures at a beach on value per day.

It is important to keep in mind that if a beach is closed to swimming, people may not go in the water, but might still pay for a day at the beach. Without additional data, our estimates cannot account for changes in consumer surplus for a visit based on water conditions (Hanemann et al. 2005, Busch 2009). We know that people are less willing to go to a beach that has a swimming advisory posted, but we do not know how much their consumer surplus would change if they did

choose to go anyway. It is also possible that when one of the beaches is closed, beachgoers would choose another nearby beach as an alternative site. The alternative beach could be one of the other beaches in Barnstable, another on Cape Cod, or somewhere else in New England. However, given the level of congestion at beaches in the region and levels of summertime traffic, substitute sites may be difficult to access and substitution to congested sites may decrease values to existing visitors at those locations. Without knowing the use of alternatives, and not knowing the change in consumer surplus for a day with a posted advisory, we may be overestimating the value of a beach closure. This may be offset by our conservative assumptions regarding total visitors (not including off-hours visitors and walk-ons) and market economic effects. Future work estimating transferable consumer surplus estimates for beach visits with and without a beach closure and identifying site alternatives would fill important gaps in the literature.

Improved water quality through stormwater management or other water quality projects can lead to fewer days closed due to exceedances in bacterial concentrations. Altogether, the four beaches analyzed in this article had a closure at least once within the five years of our study (2011-2015), leading to a reduced consumer surplus. From the meta-regression, if there were no closures in the past five years, the consumer surplus for Barnstable beaches would have more than doubled. As a result, the seasonal value of all four beaches if they were “pristine” in quality would amount to about \$9.2 million dollars in economic value, as compared to the projected \$4.3 million. This highlights the significance of stormwater management and other water quality projects that can help improve the reputation of the beach, and therefore increase the non-market value of a beach day.

However, stormwater management, improvements in wastewater management, and other types of water pollution prevention are not easy. The policy efforts take many years to implement and the infrastructure can be expensive to install. Valuing coastal recreation helps to provide decision-makers with additional information about why protecting coastal waters is so important by showing the relative scale of the benefits the public receives from these resources. Putting these public values in economic terms also helps provide a communication tool that relates the amount spent to protect the environment to the value of services received through improved protection.

4.1 Future Applications

There are many parts of this study which have useful applications in other settings. Our meta-analysis of consumer surplus for beach and swimming days can be used in areas of the United States other than New England and can be applied to freshwater or saltwater beaches. The addition of site attributes available from EPA's BEACON database led to a richer dataset in our application, including the addition of a water quality proxy, which illustrated the potentially large differences in value between beaches with and without closures. These data are available for beaches across the United States (U.S. EPA 2016). Benefit transfer methods necessarily use strong assumptions and simplifications of the factors that lead to a consumer surplus value. In surveying the literature for relevant values for our application and future similar efforts, it became clear that there is a lack of studies that apply existing methods in a consistent way across time or in different locations. A bias towards novel and complicated methods in publications is limiting the ability of practitioners to use the type of economic information that non-market studies are designed to provide (Boyle et al. 2017). The scarcity of comparable estimates also limits the ability to take into account important differences in study and policy applications (Loomis and Rosenberger 2006).

We intended our visitation model to be transferable across the town of Barnstable and for similar beaches on Cape Cod. Our visitation model may be scalable to other beaches and access points on Cape Cod, using parking spaces as the major proxy for attendance. Future research will examine the wider transferability of this model, and additional methods for valuing coastal recreation as it relates to water quality for Cape Cod and New England.

The models fit in this paper will also inform future research that aims to value the recreational use in estuaries with impaired water quality. While major beaches, which tend to be on more open water, are sometimes affected by closures, smaller beaches, which tend to be within semi-enclosed waterbodies, are more affected by excess bacteria and nutrients. In addition to closures resulting from bacteria, excess nutrients can lead to diminished aesthetics and potentially more serious impacts such as algal blooms and fish kills. Yet, visitation records for these smaller beaches are often unavailable. How the type of models we fit to public beaches with parking fees translates to estimating visitation to smaller access points along more embayments is an area of ongoing research.

5. CONCLUSIONS

Information on the economic value of coastal resources and the extent to which they are at risk from pollution can be helpful in many decision-making settings and public processes. Valuing coastal recreation helps to provide decision-makers with critical information about the importance of protecting coastal waters by demonstrating the magnitude of the benefits the public receives from these resources. Presenting the value of beaches and the lost value due to closures in widely relatable and understandable monetary terms provides a useful communication tool, because non-market benefits are a large and often missing part of the discussion.

The beaches of Cape Cod are valuable to its local economy and provide large social benefits in the form of consumer surplus, but closures on the Cape are relatively rare compared to other parts of New England and the United States. Calculating the value of beaches and lost values due to closures in other areas could contribute a deeper understanding of how important these resources are to local economies and to society, by providing estimates of economic value for a significant and popular aspect of coastal use.

As more site-specific and current studies of coastal recreation become available, our ability to provide accurate and generalizable information will improve. In this paper, we provide information and methods that can be used to estimate the value of beach days and losses that may result from degraded water quality, using readily-available data and the current state of the literature. Our work fills a gap in knowledge that can assist in assessing town and regional water quality efforts both on Cape Cod and in coastal communities more broadly.

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