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Application of non-market valuation to the Florida Keys marine reserve management

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Abstract

The quality of the coral reefs in the Florida Keys is essential to sustain nature-based tourism in the Keys. The recently established marine reserves (MR) are expected to improve the reef environment, particularly coral and fish abundance and diversity. In this paper, a combined model of travel cost and contingent behavior was estimated in order to measure the non-market recreational benefits of reef quality improvements. The results indicated that an average visitor would undertake 43–80% more number of trips to the Florida Keys and experience a 69% increase in the use values per trip, as a result of the MR-induced reef quality improvements. The above non-market value estimates were further applied to evaluating alternative management proposals for funding the MR program. It was found that the annual management costs of the MR program would constitute an insignificant portion—only around one to 2%—of the annual recreational benefits that the MR would generate. The results provide a strong economic justification for designing user-based funding mechanisms in order to make the MR program self-sustaining in the future.

Keywords: Marine reserves; Coral reef; Travel cost method; Contingent behavior model; Panel data; Non-market values; Recreation; Florida Keys

1. Introduction

Nestled in the warm Florida's marine environment, coral reefs are unique ecosystems that are known for their aesthetic beauty and provide habitat for numerous biological species. They also help protect the coastline from erosion by reducing the energy of incoming waves. Economically, the coral reefs provide the basis for the two most important, yet conflicting regional industries: fishing and tourism. They are the major fishing ground for lobster, snapper, and mackerel, and are credited for generating at least $60 million a year for the industry (US Department of Commerce, 1995). The tourism industry depends on coral reef, attracting thousands of recreational boaters, divers, snorkelers, and glass-bottom boat users to the region. These visitors spend more than $1.2 billion in South Florida, which has a potential of producing $2.94 billion in total output and $1.69 billion in income throughout the regional economy. As a result of increasing demands for access to the coral reef for recreational and commercial uses, this marine ecosystem has shown signs of unsustainability in recent years. At the current rate of degradation, the Florida coral reef is expected to disappear in less than 10–25 years unless restoration efforts are immediately launched (The New York Times, 1994).

In response to the rising concerns of the unsustainable Florida coral reef environment, Congress designated the Florida Keys as a national marine sanctuary in 1990 and delegated the management responsibility to the National Oceanic and Atmospheric Association (NOAA) (US Department of Commerce, 1995). In early 1995, NOAA finalized its plan, calling for the establishment of various types of 'marine reserves' (MR), which would be off limits to commercial and recreational fishing. Three types of MR established under this plan are noteworthy. First, three 'Replenishment Reserves' (RRs) were established on a total area of 49 000 ha to provide natural spawning, nursery, and habitat for the reefs' animals, and to protect ecosystem functions. Second, nineteen 'sanctuary preservation areas' (SPAS) were designated on a total area of 1555 ha to protect shallow, heavily used coral reefs and minimize user conflicts. Third, the above plan designated certain areas hitherto managed by other local, state, and federal agencies

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as ‘existing management areas’ (EMAs), and adopted additional regulatory measures for comprehensive protection of resources.

On the one hand, commercial fishermen objected the idea of establishing new MR. In a recent survey, the Keys’ commercial fishers reported that the majority of their fishing activities took place within the jurisdiction of the marine sanctuary and that the MR would not benefit their commercial interest (Milan et al., 1997). The limited or no access to MR is expected to result in increased cost of fishing and reduced quantity of landing. On the other hand, advocates of MR maintained that the same would enhance non-consumptive, recreational benefits through improved coral reef quality and fish abundance, and reduced congestion. But the lack of empirical estimates of such benefits makes it harder for planners and the general public to justify an action that costs the regional economy.

There is little empirical information about the magnitude of the recreational benefits arising from the establishment of MR and the attendant reef quality improvement. Leeworthy and Bowker (1997) estimated the total annual use values of recreational activities in the Florida Keys under the current environmental quality using a traditional travel cost method (TCM). Their valuation provides a solid baseline estimate of recreational benefits for future comparison and monitoring purposes. However, of more policy relevance now is the valuation of MR-induced reef quality improvement prior to its actual realization sometime in the future. Such valuation may be of valuable use for marine managers in order to sustain public support through its implementation phase.

Traditionally, a variety of revealed preference methods have been used to value environmental quality improvement. The most common approach is TCM using pooled data from recreation sites with different quality levels (Smith and Desvousges, 1985; Bockstael et al., 1989). The application of this approach requires quality variation across a large number of sites (Whitehead et al., 1998). Furthermore, the observed quality variation must coincide with the quality change that is expected from the management policy under review. These requirements seriously limit the policy relevance of revealed preference techniques. In more recent studies, researchers have attempted to value quality changes at a single site by combining revealed and stated travel data (Loomis, 1993; Cameron, 1996; Englin and Cameron, 1996; Cummings et al., 1997; Huang et al., 1997; Eiswerth et al., 2000). The idea here is that both revealed and stated preference techniques will be used to observe the number of trips taken to the same site under current and new quality levels, respectively. Then these two data sets will be combined to estimate the benefits associated with quality improvement. Huang et al., 1997 find that this combined approach improves the efficiency of benefit estimation.

This study builds on previous research in several ways. First, it contributes to the growing literature on non-market valuation of environmental quality changes by using a combined revealed (travel cost) and stated preference (contingent behavior) approach. We surveyed a sample of visitors in the Florida Keys first to obtain their revealed travel preference under the current quality level. Then, a contingent behavior ‘photograph pairs’ approach (Hanley and Ruffell, 1993) was adopted to collect stated preference data from the same panel of visitors under different quality improvements. The establishment of MR is expected to result in simultaneous improvement in different quality attributes, such as coral quality and fish abundance. The photograph pairs approach allows us to easily examine the change in visitors’ recreational preference in response to each quality change separately. A panel recreation demand model was applied to the pooled data of current and expected quality scenarios in order to estimate consumer benefits as measures of reef quality improvements. Second, it contributes to the ongoing debate on the economic tradeoffs of establishing MR in the Florida Keys by valuing associated recreational benefits. The annual incremental recreational benefits of MR were estimated and compared with the current and future management costs. Further, alternative user-based funding proposals were analyzed in comparison with the expected MR-induced benefits. Thus, this study represents another unique example of how non-market economic valuation can be used in environmental decision-making.

This research was conducted as an exploratory study with an objective of providing quick, but policy-relevant estimates of non-market benefits of MR establishment. Due to a limited funding available at the time of the study, the analysis was based on a relatively small panel of visitors. The results, nevertheless, are encouraging and merit further refinement by way of collecting data from a larger sample, and based on updated information on quality changes since the commencement of the program.

2. Methods

2.1. Data collection

The primary data used in the study come from two sources: an on-site survey of recreational visitors in the Florida Keys, and personal communications with biologists at the Florida Keys National Marine Sanctuary (FKNMS) Office, Marathon, Florida. A visitor survey was conducted during the June–December 1996 period at selected reef sites. These sites represent high visitors’ activities and host certain SPA or EMA. A total of 200 surveys were administered, but all of these surveys were not usable for several reasons. The most common reason for the non-usability of responses was that the visitors were not there primarily for diving, snorkeling or glass-bottom boat rides. Some surveys also had missing information. Thus, a total of 89 responses were included in the final analysis.

The survey gathered a wide range of information from the visitors. This information included the number of times they had visited any similar sites in the Florida Keys over the past five years (revealed recreation preference), how long they traveled, what travel mode they used, and several demographic characteristics. Then the visitors were shown two sets of pictures representing main quality attributes, namely, fish abundance, water quality and coral quality. The first set represented existing quality levels of fish abundance, visibility and coral health under no management plan. The second set showed pictures of fish and coral improvements expected to occur from the new management plan. After evaluating alternative management plans, including a 'no-action' plan, NOAA has implemented what is called 'preferred management alternative' (PMA). Among others, PMA involves the establishment of MR that would provide resource protection for heavily used portions of the Sanctuary that are economically important for commercial activities such as dive operations (US Department of Commerce, 1995). This plan also will protect reef areas that support high levels of biodiversity and areas that are important for sustaining other natural resources. Further, the PMA will ensure marine species protection throughout the Sanctuary. On the contrary, the no-action plan would require the establishment of no new MR and would result in continued degradation of the reef environment.

Our goal was to measure the value of improvements in the recreational quality of coral reefs from the 'no-action' plan level to the PMA level, in terms of fish abundance, visibility in water and coral quality. Therefore, comparative pictures of fish, water and coral qualities for with- and without-PMA scenarios were selected from the photo archives of the field biologist, Ben Haskell, at the Florida Keys Marine Sanctuary Program Office. Also adopted in the study were two pictures of a certain coral reef site taken in the year 1960 and 1989 by Ward (1990). The pair of picture sets depicting fish abundance reflected roughly a 200% improvement from the no-action to PMA scenarios. The picture sets showing the underwater clarity and visibility conveyed about 100% improvement from the existing level. Similarly, the quality improvement in coral health from the no-action plan to PMA was considered 100%. After showing the visitors each pair, they were asked to indicate how many more times they would have visited during the same past five year period with the MR-induced quality improvements in fish abundance, water visibility and coral health (stated recreation preference) separately. From this survey was constructed a panel data set including both revealed and stated recreation preference data for each visitor.

2.2. Statistical model

The recreation demand data observed in this study belongs to a special class of data possessing unique features. First, the demand variable is a count of total number of visitations that each visitor undertakes during a fixed time period. Thus, observations are non-negative integers. Second, since the data was collected through an on-site survey, only visitors were included in the model. That is, non-visitors were not part of the sample. The variable, therefore, is zero-truncated. Finally, we have collected recreation demand data from the same set of individuals under different states of nature (i.e. status quo versus improved environmental quality levels). Such data is qualified to be a panel data. The panel nature of our recreation demand data suggests that in addition to the exogenous (explanatory) variables, the persistent individual (visitors) differences may also influence the level of recreation demand (Hausman et al., 1984). This means that visitors might share identical observed characteristics, but reveal and/or state systematically different choices (Alberini et al., 1997). A Poisson regression model with random effect error component can be used to capture these random response shocks across individuals (Greene, 1998; Rosenberger and Loomis, 1999).

Within the framework of a random-effect Poisson model with fixed environmental quality change, the recreation demand then can be specified as

$$\ln(Y_{iq}) = \beta_1 X_{iq1} + \beta_2 X_{iq2} + \cdots + \beta_k X_{iqK} + \sum_{q=1}^{3} \varphi_q D_q + \sum_{q=1}^{3} \alpha_q D_q X_{iq1} + \mu_i + e_{iq}, \qquad (1)$$

where Y_{iq} is the number of trips by individual i ($i = 1, 2, \ldots, N$) under a particular quality state q ($q = 0$ for status quo and 1, 2 and 3 for three types of improved reef quality); X_{iqk} ($k = 1, 2, \ldots, K$) are the regressors or independent variables; and, D_q are the dummy variables that capture the effects of three improved reef qualities. D_1, D_2, and D_3, will assume a value of one for stated recreational demand, i.e. when $q = 1$, 2 and 3, respectively, and zero otherwise. This formulation allows us to measure the shift in the demand intercept due to an improvement in the reef quality. Also included in the model are slope shifters for the price variable X_{iq1}, on the assumption that the structure of the demand curve changes with a quality improvement. Further, μ_i is the random error that arises due to persistent individual differences between visitors, and e_{iq} is the random effect for the ith individual under qth quality status.

The above demand model also allows us to estimate changes in the consumer surplus that occur due to the changes in the reefs environmental and recreational quality. Assume that X_{iq1} is equivalent of a price variable in a standard demand equation. Then, following Bockstael and Strand (1987), the per person consumer surplus under a quality level q is simply

$$\mathrm{CS}_q = \int_{X_0}^{X_c} \lambda_q \, \mathrm{d}X_{iq1} = \frac{\lambda_q}{\beta_1}, \qquad (2)$$

integrated from the beginning price X_0 to the choke price X_c that makes λ_q to become zero. Here, λ_q is both the mean and variance of Y_{iq} for quality state q. Actual consumer surplus can be estimated by substituting the estimated value of an average visitor of Y_{iq} for λ_q in Eq. (2). Now, suppose that the reef quality level changes from $q = 0$ to 1. As suggested by Whitehead et al. (1998), a visitor's recreational value of this quality improvement (i.e. the increase in the consumer surplus) can be obtained from

$$\Delta \mathrm{CS} = \frac{\lambda_1}{\beta_1^1} - \frac{\lambda_0}{\beta_1^0}, \tag{3}$$

where β_1^1 and β_1^0 are the co-efficient of the price variable in the demand model with quality levels 1 and 0, respectively. If there is no change in the coefficient of price with quality change, the value of quality improvement is simply $\Delta \mathrm{CS} = (\lambda_1 - \lambda_0)/\beta_1$.

2.3. Model variables

The dependent and explanatory variables used in the empirical models are constructed on the basis of past research (Leeworthy and Bowker, 1997; Whitehead et al., 1998) that showed that the visitors' recreational preference was related to visitors' characteristics, travel distance, and environmental quality of travel sites. The dependent variable, travel demand (Y_{iq}), was defined in terms of a person-trip. That is, each respondent's total travel demand was computed as the total number of trips that this individual makes in a given period times the number of persons traveled together during the current trip. As Leeworthy and Bowker (1997) note, this definition is more appropriate since group travel by car is very common in the Florida Keys.

The travel cost variable was defined in the following manner. Most visitors interviewed used either auto to travel to their destination in the Keys, or flew into Miami and then drove rental cars to the Keys. The travel distance was calculated as the minimum round trip distance from their hometown to a given site in the Keys for those who used only auto. For those who used multiple modes of transport, distance was calculated as minimum round-trip distance from their hometown to Miami International Airport *plus* round-trip distance from Miami to a given site in the Keys. Also, for people whose sole purpose of the current trip was not recreation, we assumed that they traveled from Miami to the site of their destination in the Keys.

Based on a fairly large sample, Leeworthy and Bowker (1997) developed group trip costs of 0.14/mile for auto-only mode and 0.30/mile for multiple modes. In comparison with estimates done in 1989, the above trip costs had remained fairly stable over a long period (*Personal communication* with Bob Leeworthy, 2002). However, following an anonymous reviewer's suggestions, the multiple modes trip costs were revised slightly. For one-way air travel distance of less than 500 miles, the trip cost was assumed to be \$0.30/mile. For air travel distances of 500–1000 miles, 1000–2000 miles and above 2000 miles, the costs were assumed at \$0.26/mile, \$0.22/mile and \$0.18/mile, respectively. A sensitivity analysis was also done using the original trip mileage costs of Leeworthy and Bowker.

The final travel cost per person-trip was computed by multiplying the total round-trip distance by the above per-mile group trip costs, and then, by dividing the result by the number of persons in each group. Some researchers recommended that the opportunity cost of trip time be included in the travel cost (Bockstael et al., 1989). Most people in the labor market face 40 h, all or nothing labor contract, which suggests travel time does have a scarcity value. Furthermore, travel time also has a disutility value, particularly for long-distance road travelers. However, others reject this notion for empirical and theoretical reasons (Freeman, 1993). Most visitors we interviewed visited the Keys either on weekends or during their annual vacation; therefore the likelihood that they lost an opportunity to earn income during their trip to the Keys was considered negligible. Thus, we decided not to include the opportunity cost of time into the travel costs. The final TC values were expressed in hundreds of dollars per person per trip.

Recognizing that there was a wide variability in the nature of trips taken by sample visitors to the Florida Keys, we included five different variables to separate out the influences of trip characteristics. The first one was a dummy variable accounting for the single-day trips, which took a day or less. Most of these trips were made by South Floridians who we suspected were significantly different from visitors coming from other states or countries because of their experience with the Key resources. We also expected that the length of trip would have a significant influence on visitation rate. In addition, we introduced an interaction variable between trip length and the travel cost variable. A binary variable to test the influence of seasonal nature of trips was also included. Summer visitors were expected to visit Florida Keys more often than those who did during winter. Finally, a dummy variable measuring the visitors' prior experience visiting the Florida Keys for recreation was added to the model, and this variable was expected to have a positive effect on the travel demand.

Recreational demand also was assumed to depend on demographic factors, namely per capita household income and age. In the survey, information on household income was collected in terms of ranges of income. The range values were converted to mid points of income intervals and then divided by the family size. Also, in order to avoid the problem of non-convergence in estimating the statistical model, the final values were expressed in 10 000 dollars. Age in years was expected to be positively related to the number of trips.

Three dummy variables representing the MR-related reef quality improvements were included in the final estimating model. These variables reflect higher level of reef environmental quality in terms of increased fish abundance, underwater visibility and improved coral quality. A value of

1 for each of these variables means improved environmental quality due to the MR establishment, and 0 means current reef quality. Finally, we tested for differences in the slope of the demand curve between revealed and stated preferences, by adding two travel cost interaction terms, one each with water quality and coral quality dummy variables.

In estimating the model, we merged the revealed preference data (representing the existing quality level) with three sets of stated preference data (representing demand under three different quality states). The LIMDEP software program was used to estimate the random-effect Poisson regression model with the panel data estimator. After estimating the model in Eq. (1), we computed the estimated values of trips (Y_{iq}) under all the quality scenarios $q = 0,1,2,3$. For this calculation, the X_{iqk} variables were held at the sample means (Table 1). The quality variables D_q were set equal to one for scenario q, and 0 otherwise. The difference between the estimated trip for an improved quality scenario and that for the status quo would give the quality-induced trip increase for each scenario. Then, we computed consumer surplus estimate for each scenario and the change in surplus for all the improved quality scenarios.

3. Results of travel cost model

3.1. Determinants of travel demand

Estimation results of the recreation demand model are reported in Table 1. The model was corrected for zero truncation. Several alternative specifications other than those reported in the table were examined. One of these specifications included variables of interaction between travel costs and fish abundance dummy variable. This specification did not yield meaningful results. We also tried including opportunity costs of trip time and sex. These variables were either statistically insignificant or made the statistical convergence during model estimation too difficult.

All the estimated coefficients emerged with expected signs. All but three variables were found to have statistically significant relationships with the recreation demand at conventional levels of probability (less than 10%). An increase in the travel costs resulted in a statistically significant decrease in the demand, as hypothesized. The coefficients of age variables suggested an inverse relationship between age and the number of trips, meaning younger people were more likely to visit the Florida Keys. The positive sign of the coefficients of the per capita income variable was consistent with our expectation. However, both age and income variables were not statistically significant. Various past travel cost studies have also found similar insignificant influence of income on travel demand.

As hypothesized, the significance level and the positive sign of the coefficient of the single day trip variable confirmed that single day travelers, who were mostly from South Florida, made significantly higher number of trips to the Keys. The trip length variable proved to have a negative influence on the demand. The sign of the travel-cost and trip-length interaction term was positive, as expected. This showed that day travelers and longer-duration travelers would respond differently to an identical change in the travel costs. The summer visitor dummy variable came out with a positive and significant co-efficient to indicate that summer was a more popular time of the year for visit to the Florida Keys. The prior experience of the travelers showed a positive and significant influence on the individual travel demand.

Finally, the three intercept shifters were significant at high levels of probability. This strongly supports the view

Table 1
Random-error poisson regression model of revealed and stated trips to the Florida Keys

Variable	Poisson model regression co-efficient	t-Value	p-Value	Sample mean
Intercept	1.883	3.53	0.000	1
Travel costs ($100)	−0.188	−2.57	0.010	2.92
Age (years)	−0.010	−0.86	0.391	35.2
Per capita income ($10 000)	0.022	0.24	0.811	3.024
Single day trip (1 = yes, 0 = no)	1.193	2.32	0.020	0.08
Trip length (days)	−0.241	−2.73	0.006	3.79
Travel cost-trip length interaction	0.021	1.74	0.082	19.08
Season (1 = summer, 0 = winter)	1.019	2.68	0.007	0.63
Prior experience (1 = yes, 0 = no)	0.875	3.72	0.000	0.66
Higher fish abundance (1 = yes, 0 = no)	0.582	21.55	0.000	1
Improved water quality (1 = yes, 0 = no)	0.368	8.66	0.000	1
Improved coral quality (1 = yes, 0 = no)	0.190	6.59	0.000	1
Travel cost-water quality interaction	0.038	1.50	0.133	2.92
Travel cost-coral quality interaction	0.057	2.43	0.014	2.92
Alpha	0.640	5.19	0.000	
Log likelihood function = 18 763	$\chi^2 = 37\ 527$	Significance level = 0.000		
Sample size = 4 panel data sets and 89 individuals				

All the coefficients with p-values less than or equal to 0.01 and 0.05 are significant at 1 and 5% level, respectively.

that users will positively respond to the MR-induced improvement in three qualities of the reef under investigation. The coefficients of the interaction of travel cost with water quality and coral health dummy variables were positive as hypothesized. While the water quality interaction variable was not significant at conventional level of probability (10%), its p-value of 0.13 was fairly low. Travel cost-coral quality interaction variable was found to be statistically significant. These results supported our view that visitors would respond differently to a price change under the current and improved quality scenarios. The Chi-square measure of goodness of tit ($p = 0.0$) suggested the estimated model coefficients were significantly different from zero.

3.2. User values of reef quality improvement

The main purpose of the empirical model in this paper was to estimate the non-market value of the reef quality improvement that resulted from MR establishment under the PMA. Using Eqs. (2) and (3) and the estimated coefficients of travel cost variable, we first computed the per person use values (CS) under current reef quality scenario (no-action plan), and per person value of each quality change (ΔCS). Further, per person CS estimate was converted to per trip use value by dividing CS value by the estimated number of trips an average person made at the respective quality levels. The change in the CS per trip due to a quality improvement was computed by subtracting the per trip CS of the current quality from that of the given improved quality. The visitors were expected to simultaneously enjoy incremental levels of three reef quality attributes. Therefore, the aggregate incremental utility of the three quality attributes was computed by summing the incremental utilities of individual attributes.[1]

The use values per person and per trip, in terms of consumer surpluses, are presented in Table 2. An average visitor made an estimated 6.31 trips to the Florida Keys over the study period of 5 years for the purpose of diving, snorkeling and/or glass-bottom boat riding at the current quality. The use value from these trips was estimated at \$2924.[2] This estimate converted to a per person-trip user value of \$463 and a per day value of \$122. Our estimates were relatively lower than the per-trip estimate of \$741 reported by Leeworthy and Bowker, 1997, p.20) for visitors going to the Florida Keys in 1995. This difference (about 38% less) was primarily due to the lower per trip mileage costs considered in our analysis. An alternative model also was estimated using the per-trip costs of 0.14/mile for auto-only modes and 0.30/mile for multiple modes. This alternative model estimation yielded a per-trip consumer surplus estimate of \$750, which was very close to the Leeworthy and Bowker's, 1997 estimate of \$741. As expected, travelers who visited the Florida Keys for a day or less for recreational activities derived a use value of \$6,757 per person, or \$384 per trip. Note that this per trip value is much less than the value for an average visitor of \$463.

With improvements in fish abundance (200%), water visibility (100%) and coral quality (100%) characteristics considered to occur due to the PMA, an average visitor was predicted to make 4.99, 3.88 and 2.70 more trips during the five-year period, respectively. The largest user value appreciation was estimated to occur from the improved coral quality by an amount of \$3080 per person, followed by improved underwater visibility by \$2,993 per person. The total increase in the use value of three quality attributes combined was \$8,382 (a 287% increase). On a per trip basis, the use value of the reserve was found to increase by \$320, or up 69% from the no-action use value of \$463 per trip. Similarly, on a per day basis, the total use value increased by \$84 (69%) from the current level.

Morey (1994) shows that when site characteristics change, the CS per day of recreational use will become a variant in the number of days of use. What we have in our study is a constant per-day CS, independent of the number of days of use. If the per-day value of trip is multiplied by the annual number of predicted days of use under the original quality state, one would only get a lower-bound, linear approximation of the true valuation. Our model lacked the necessary variable to estimate the trip-length variant per-day CS. However, based on Morey's proposition, we consider our valuation the most conservative one. Also, our management application of CS to be explained in Section 3.3 is mostly based on the per-trip and per-person use estimates.

3.3. Applications of non-market valuation to MR protection

Recreational benefits are an important part of the overall natural asset value of the coral reef in the Florida Keys. Appreciation in the asset value of recreation has been one of the justifications for securing public funding for protecting the reefs. In this section, we explain how the study results could be of use for agencies to make various management decisions.

One of the most critical challenges that the FKNMS might face in the future is securing increased public funding for enforcing MR regulations. Fortunately, there has been a steady increase in the funding for the overall program in the past, from \$1.437 million in the year 1992 to \$3.417 million

[1] The aggregate incremental value as computed here is the maximum limit. In actuality, if the MR improves, say, only one of the attributes, the actual change in value would the incremental value of only that attribute.

[2] Per Zellner and Park (1979) and Bockstael and Strand (1987), the coefficient of the travel cost variable might be unbiased, but the consumer surpluses estimated thereof (Eqs. (2) and (3)), might still be biased. Therefore, these estimates were corrected by multiplying the same with a correction factor of $l/(1 + (t)^{-2})$, where t is the t-value for the travel cost variable coefficient. In computing consumer surplus estimates for the day travelers, the correction factors of both travel cost and cost-trip length interaction variables were multiplied by the consumer surplus.

Table 2
Trip response and user value increase from coral reef quality improvements

Indicators	Reef quality states[a]				Total of the three Improved scenarios
	Current	Improved Fish Abundance (by 200%)	Improved Water Quality (by 100%)	Improved Coral Quality (by 100%)	
Estimated number of trips per person (for five year period) (T)	6.31	11.30	10.20	9.02	
Changes in the no. of trips due to Reef improvement per person (ΔT)	–	4.99 (80%)	3.88 (61%)	2.70 (43%)	
Consumer surplus (CS) per person ($)	2924	5233	5918	6004	
Change in CS per person ($)	–	2,309	2,993	3,080	8382 (287%)
CS per person-trip ($) (E)[b]	463	463	580	666	
Change in CS per person-trip ($)	–	0	117	203	320 (69%)
CS per day ($/day)	122	122	153	176	
Change in CS per day ($/day)	–	0	31	53	84 (69%)

Number in parentheses represents a percent change in the value of the improved scenarios over the value for the current scenario level.
[a] The assumed changes in the three quality attributes were as follows: a 200% increase in the fish abundance and a 100% increase in both underwater visibility and coral health.
[b] Sensitivity analysis was done using the trip travel costs of $ 0.14/mile for auto-only mode and $ 0.30/mile for multiple modes Leeworthy and Bowker (1997). The estimated number of trips/person in five years (CS/trip in dollars) in this case were 3.88 (750), 6.94 (750), 6.22 (940) and 5.48 (1,068) for the current, improved fish abundance, improved water quality and improved coral quality scenarios, respectively. For the same analysis, the per-day CS values for the four scenarios were in dollars 147, 147, 185 and 210, respectively.

in the year 2000 (personal communication with Patti Hartsing, FKNMS, Marathon, Florida, 2001). This was expected to further increase to $4.415 million in the year 2001. However, the current annual funding level falls short of the full plan implementation costs. With inadequate federal funding in the future, the agencies might like to explore alternative modes of financing their management programs.

Previous surveys conducted in the region (Milan et al. 1998) indicate that the overall support for the MR from the locals is very low. This suggests that full or partial financing of FKNMS program through new taxes on resident population may not be politically appealing.

Since the Florida Keys and Key West still remain attractive tourist destinations, one might find it ethically comforting and economically justifiable that recreational users, the majority of whom come from out of state, be charged an additional fee. In designing such a proposal, the agency would need to know at least: (a) whether the MR-induced recreational benefits are sufficient to offset the additional recreational fees; (b) some idea of tax rates, and (c) alternative modes of user fees or taxes which might appear to have varying consequences. Our model results can be used to address some of these management questions intuitively.

We computed the total value of additional recreational benefits (ΔB) created by the MR-induced reef quality improvement. Here, only snorkeling- and diving-related recreational activities were considered in computing MR-induced increase in recreational benefits. The change in the use value of MR occurs primarily through changes in the number of trips (T) that each person undertakes, and the trip values associated with each of the quality attributes.

Therefore, the total ΔB can be expressed using the following formula,

$$\Delta B = P \sum_{q=1}^{3} E_q \Delta T_q, \tag{4}$$

where P is the number of full-time person equivalent that engaged in snorkeling and scuba diving in the Keys, E_q is the use values per trip under the improved quality scenarios q, and ΔT_q is the change in trips per person under q.

Leeworthy and Bowker (1997) reported that tourists spent 2.237 million person-days on snorkeling and scuba diving in the Florida Keys during the 1995–1996 year. Of these, the out-of-state travelers spent 2.058 million person-days. For our sample, the number of days an average individual would spend snorkeling and diving was estimated to be 4.79 days/person/year. Dividing this number into the total annual person-days of 2.058 million resulted into the annual full-time person equivalent of $P = 0.43$ million. The values of E_q and ΔT_q, are reported in Table 2. Plugging these values in Eq. (4) resulted an annual total increase in the MR-induced recreational benefits of $547 million (see Table 3). Note that this increase does not include the value experienced by new visitors that the MR may generate.

Using per-trip expenditure data estimated by English et al. (1996) for the Florida Keys visitors, we computed the annual trip expenses that snorklers and divers incurred in Monroe county (Table 3). This expenditure was further

Table 3
An analysis of alternative financing mechanism for marine reserve protection

	Items	Units	Amounts				
	I. MR-induced non-market values		Quality scenarios				
			Current	Improved Fish	Improved Water Quality	Improved Coral Quality	Total
a	Consumer surplus	\$/trip	463	463	580	666	
b	MR-induced annual change in trips	Trips/person	0.00	1.00	0.78	0.54	
c	Per-person incremental benefits of the reserve	\$/person/year	0.00	462	451	360	1272
d	Annual snorkeling and diving activity[a]	Million person-days	2.058				
e	Estimated number of trip-days per person	Trip-days/person/year	4.79				
f	Estimated number of person-visitors for snorkeling and diving $[(d)/(e)]$	Million person/year	0.43				
g	Annual increment in the use value for snorkelers and divers $[(c)\times(f)]$	Million \$	0	198	194	155	**547**
	II. Travel expenditure		Lodging	Food/beverage	Transportation	Diving	Total
h	Total trip expenditure[b]	\$/person/trip	282	192	231	13	900
i	Expenditure per day[c] $[(h)/6.25$ days$]$	S/day	45	31	37	2	144
j	Percent of (i) spent in Monroe county[d]	Percent	59.8	65.6	20.0	93.6	50.1
k	Portion of (i) spent in Monroe county $[(i)\times(j)]$	\$/day	27	20	7	2	72
l	Annual travel expenditure incurred in Monroe county $[(d)\times(k)]$	Million \$	55	41	15	4	148
	III. Potential sources of funding MR and cost burden on users		Alternative budget requirements and taxes				
			2001 level	Plus 25%	Plus 50%	Plus 100%	
m	Annual FKNMS budget needs	Million \$	4.415	5.519	6.623	8.830	
n	Percent of snorkelers/divers of the total nature-based tourists[e]	Percent	22	22	22	22	
o	FKNMS budget attributable to snorkelers and divers $[(m)\times(n)/100]$	Million \$	0.950	1.187	1.424	1.899	
p	Expenditure taxes on (l) sufficient to meet the FKNMS annual budget (o)						
	Lodging	Percent	1.71	2.14	2.57	3.42	
	Food and beverages	Percent	2.29	2.87	3.44	4.58	
	Transportation	Percent	6.23	7.79	9.35	12.47	
	Snorkeling and diving	Percent	23.09	28.56	34.64	46.18	
q	FKNMS' partial budget as % of the reserve's use value $[100(o)/\text{total of }(g)]$	Percent	0.17	0.22	0.26	0.35	
r	FKNMS' total budget as % of the reserve's use value $[100(m)/\text{total of }(f)]$	Percent	0.81	1.01	1.21	1.62	

[a] Source: Leeworthy and Bowker (1997), p. 2 1. Their original aggregate number was adjusted to exclude 8% of travelers who undertook a day long or shorter trip.
[b] Source: English et al. (1996), p. 11, Table 6. The Averages of June-November, 1995 values and December–May 1996 values.
[c] Per-person trip is divided by the average length of trips of winter and summer seasons, 6.25 days (Leeworthy and Bowker, 1997, Tables 3 and 4).
[d] Source: English et al. (1996), p. 11, Table 6.
[e] Source: Leeworthy and Bowker (1997), Tables 9 and 10.

categorized into various item-wise budgets such as lodging, transportation, food and beverages, and snorkeling and diving, exclusively spent in the local county area. The item-wise expenditure pattern would be helpful for a better understanding of alternative bases of designing user fees or taxes, to be explained later.

Next we looked at alternative levels of the FKNMS's annual budgets. Again from the data reported by Leeworthy and Bowker (1997), we found that snorkeling and diving activities constituted 22% of the total nature-based recreational activities. One might argue at least as many percents of the FKNMS's annual budgets be compensated by snorkelers and divers who seem to be the most direct recreational beneficiaries of MR. The corresponding annual budget was estimated to range from \$0.95 million to \$1.90 million depending on the future needs. Then, we computed the percentage ratios of these budgets to various expenditure items reported above, and the MR-induced annual non-use values, These percentages can be viewed as likely additional taxes that the travelers might pay on various expenditures that they incur locally (Table 3).

First of all, the increased tax burden is likely to form a very small portion of the total MR-induced recreational benefits, ranging from 0.17% for the 2001 budget to 0.35% for double-the-2001 level. Even if the entire FKNMS' budget is financed by new taxes on travelers' expenditures, this tax burden ranges only from 0.80 to 1.62% of the annual additional recreational benefits of MR. However, the real management challenge is what the best mode of raising this tax is. Visitors spent the most amounts of money on lodging and food and beverages. Thus, the proportionate increases in tax on these two items would seem to be lower, even if the entire FKNMS's budget were to be met by tax revenue. The proposed tax increase ranges from 1.71% (for 2001 level) to 3.42% (for twice-2001 level) on lodging, and 2.29% (for 2001 level) to 4.58% (for twice-2001 level) on food and beverages. The proportionate tax increases seem to be the highest if the agency were to resort to taxing snorkeling and diving expenditures, given the least amount of money spent on this item (23.09% for 2001 budget to 46.18% of twice-2001 budget). In a real life situation, smaller percentage increases in the service costs may not face stiff resistance from the users or the service providers. Therefore, the lodging and food taxes seem to be the logical choices in this case. However, there is a practical problem in targeting lodging or food taxes on only those who visit the Keys for underwater activity. Knowing higher taxes for these activities, no one might admit to being a diver.

Tax increases on snorkeling and diving expenditure may be more practical and justifiable from a different viewpoint. Users might treat a tax on expenses that are made directly in connection with a recreational activity less harshly than a tax on expenses incurred in connection with activities (i.e. lodging, food, etc.) that are distant from recreation itself. For instance, a tax on diving gears and diving activity might be more feasible. As indicated above, the proposed tax increases constitute a negligible portion of the MR-induced benefits. The users compare the additional user fee on diving with a large expected recreational benefit, and thus, are unlikely to object the fee increase. However, that this tax forms a sizable portion of the snorkeling and diving expenditure could draw stiff resistance from service providers, such as diving tour operators and equipment renters. Therefore, the resource agency may need to attempt a combination of tax strategies. Also, a further analysis is warranted to investigate economic and political implications of alternative financial mechanisms for the local governments and businesses.

Many times management agencies attempt to base their decisions on both society's needs and ecological needs. We found in our study that visitors responded to the improvement in coral quality with the largest amount of additional use value per trip. The managers of the FKMSP may very well use this information in targeting their investments on different MRS. That is, based on this result, FKMSP managers would find it rational to put the most emphasis on MRs needing coral health improvement. Such a strategy would maximize returns to public investments. However, public investment decision may not be solely based on the added recreational benefits to the reserve management. The agencies might want to carry out a full benefit cost analysis, comparing the added benefits of MR with the opportunity cost to commercial anglers in terms of their net loss in the fishery profits.

The model predicted that there would be a significant increase in the number of trips, in response to quality improvements (between 43 and 80% depending on the attributes). This raises a serious management question whether the tourist sites in the Florida Keys have the 'capacity' to handle the increased tourism. While quality improvements in the underwater reefs may bring additional visitors and add economic value to the natural resource base, on-shore facilities (transportation, lodging, information, etc.) may not be adequate to meet this new demand. Also, the diving and snorkeling sites themselves may become overcrowded, which could result in the loss of visitor satisfaction. As Davis and Tisdeld (1995) pointed out, this increased consumer surplus needs to be protected by reduced tourism value due to possible crowding effect, a syndrome often characterized as 'tourism destroying tourism'. Both tourism and resource agencies collectively need to revisit the Keys' carrying capacity in terms of tourism, development and reef protection.

4. Conclusion

In this paper, we have attempted to measure the increase in recreational demand, and in turn, to estimate the additional benefits that are expected to occur from MR-induced improvements in the coral reef quality in the Florida Keys. For this purpose, we applied a combined revealed and stated travel data technique. The technique involved estimating a modified travel cost demand model, by combining data on revealed trips under the current reef quality, and stated trips under the expected improved quality.

Overall, the statistical model did a good job of explaining the recreational demand for the Keys' resources and identifying the variables that influence the demand. All but three estimated model coefficients and the overall model fit were statistically significant. The model also estimated the increases in the number of trips and in the economic values of recreation. These increases were attributed to reef quality improvements that the NOAA's PMA plan would bring about. With improvements in fish abundance and coral health attributes, the model predicted significant increases in the number of trips taken by visitors. In view of this, the local planning and resource agencies must ask whether the recreational amenities in the Keys can handle such increase in the tourism activities.

Using the estimated economic values of change in the recreational quality of the MR, the study developed a case for alternative means of funding the future MR programs. We found that the MR-induced incremental benefits of recreation were large enough to provide justification for a user-financed marine protection program. Possible alternatives include increased expenditure taxes on diving and snorkeling activities, room and meals, and transportation services. Not all of these tax modes may be feasible. Taxes on diving gears and activities seem more plausible. The levels of expenses incurred by travelers vary widely across expenditure categories. Therefore, different tax rates may need to be applied on different categories to collect a given amount of money to support marine programs. However, designing a user-fee program requires further investigations into political and economic implications for service providers. Both service providers and recreational users might perceive fee increases on different services differently. While our study clearly provided justification for establishing user fees in support of sanctuary protection program, the broader implications of such management fees are subject to future study.

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