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The Recreational Cost of Coral Bleaching- a Stated and Revealed Preference Study of International Tourists

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Abstract

The welfare loss of a *de facto* ecological damage at an internationally visited recreational site was estimated by comparing stated preference information from before and after the actual change in quality occurred. Estimates for access to the site and for access to coral reefs before and after coral bleaching and mortality hit the West Indian Ocean in 1998 were derived using the cost of the trip as a payment vehicle. The model assumes that these sorts of trips are indivisible in consumption. It was found that despite losses in utility due to bleaching the visitors still visit the sites. Explanations are found in that the visitors are not informed about the decreased quality of the reefs and in that the site is not congested and thereby still able to provide the good demanded by the visitors.

Introduction

Nature based and outdoor recreation, including activities such diving and snorkelling is becoming increasingly popular. While the number of dive certificates is being issued at an exponential rate, coral reefs, a major attraction for divers and people snorkelling, are steadily suffering from human impacts and natural catastrophes. The latest major event, which coincided with *El niño* in 1997/1998, caused widespread coral bleaching and mortality in tropical waters all around the world. One of the affected areas was the West Indian Ocean where the event was reported to be one of the most serious natural catastrophes ever. In this paper the recreational welfare loss caused by this event is studied at two islands, Zanzibar and Mafia, typically visited for their pristine coral reefs, situated outside of Tanzania in the West Indian Ocean.

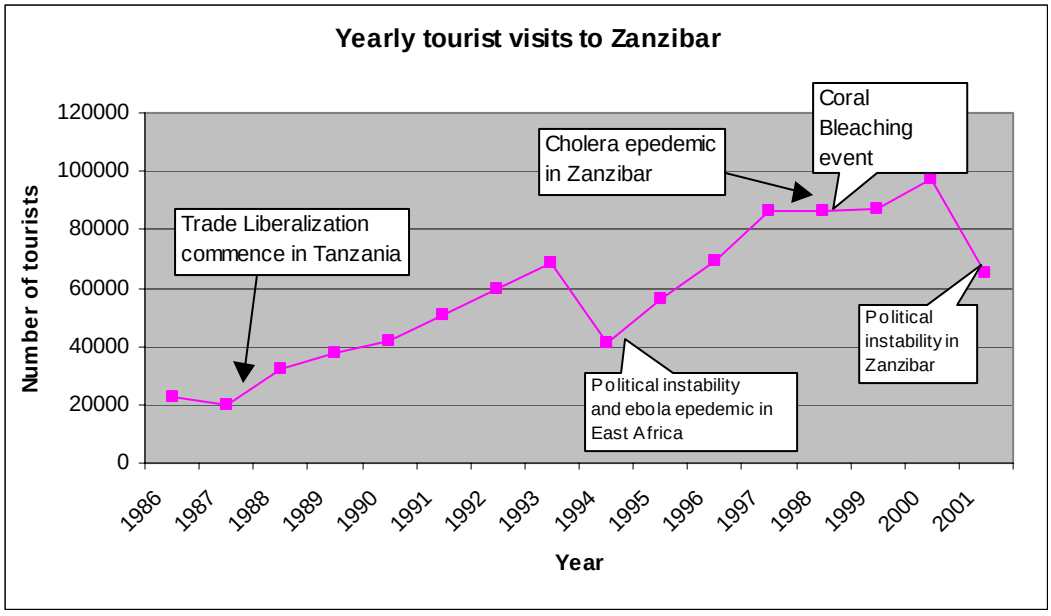
An on-site study estimating the value of access and the value of quality changes of the reefs *before* the bleaching event was copied and redone *after* bleaching had taken place. The survey applied stated preference questions using the cost of the trip as a payment vehicle. The welfare loss of the *de facto* ecological damage is estimated by comparing stated preference information from before and after the actual change had occurred. This compares with a "natural experiment" measuring the value of an actual unit of change. In addition, the fact that a real quality change takes place permits the simultaneous use of revealed preferences measuring the value of the same quality change, which is otherwise not possible given only on-site information.

Biological assessments of the reefs at the two sites documented radical changes in coral coverage after the bleaching even where coral cover at monitoring sites in Mafia decreased from 73% to 19 % and similarly in Zanzibar from 46% to 32%

[1] I am grateful for comments and discussions with Fredrik Carlsson, Thomas Sterner and Peter Martinsson during the process of producing this paper.

between 1997 and 1999 (Obura, 2002). The number of fish was on the other hand documented to remain the same and even to increase (Bergman and Öhman, 2001). But while the number of fish remained the same or increased the composition had changed to more herbivore species and less coral reef fish (Mohammed *et. al.* 2002). Coral reef fish are in general more colourful and spectacular compared to herbivore fish.

The visitation data seem to show more sensitivity to other external factors than a natural catastrophe such as the coral bleaching event. Especially political instabilities and epidemic outbreaks affected people's visiting behaviour and this is even when those types of incidents did not occur in the same country. There was a cholera outbreak during the same period as the bleaching which was well covered in media in Europe and supposedly would contribute to the slowing down of the increase in visitation rate. Similar non-decreasing figures from bleaching were found in other areas in the region, the Maldives, a well-known diving destination also severely affected by the bleaching in 1998, for example, showed increasing figures of tourist arrivals in both 1998 and 1999[2] and this is despite extensive coral mortality (Zahir, 2000). There are a number of possible explanations to why decreased coral quality did not affect the tourist behaviour. The fact that the good is lumpy or indivisible might be one explanation since it alleviates the individuals' ability to adjust behaviour to small changes in quality. Another reason can be that the tourists are not informed about the changed quality or that there is a lag in behavioural responses to these sorts of changes, or that it simply does not matter to them. It might also be that the number of visitors remains constant but have different preferences, *i.e* there is a shift of market segments. Or since the event was global the *relative* quality of the reefs compared to substitute sites might not be worsened. The event could even have the perverse effect that it attracts visitors who are curious or wants to see the reefs before they "disappear". A few questions were added in the end of the questionnaire administered *after* the bleaching event to assess these possibilities, including questions about the knowledge of bleaching and how it affected the choice of holiday site.



Graph 1. Yearly Tourist visits to Zanzibar between 1986-2001 (Source: Zanzibar Commission for Tourism)

[2] Source: Maldives Ministry of Tourism (1997, 2000). The number of visitors increased by 8% both years.

The theoretical background to the model is developed in Andersson (2003), treating the visits as indivisible in consumption. The indivisibility characteristic, that the good is either consumed once or not at all, was epitomized in the empirical sample where 90% visited the respective islands for the first time, emphasising the single visit character. Similarly did 90 % of the individuals originate from a country situated very far away with high costs both in time and money attached to a visit meaning that the likelihood of frequent visits was small. The variance in the number of days the individuals stayed at the site was considered small enough to define all trips as the same good. On Zanzibar the majority of both multi-site and single site visitors stayed between one and two weeks and the respective averages of the multi and single-site visitors differed with only one day carrying the same median[3]. Given the fact that the trip to the region constituted such a large part of the overall trip, the variance in the number of days at the site was considered acceptable.

While both islands were surrounded by pristine coral reefs they differed in their provision of alternative recreational attributes. Zanzibar has a long history as a commercial centre for Indian Ocean trade with an architecturally unique town centre accommodating shops and certain nightlife. Mafia is less accessible and provides few alternatives to its pristine marine and coastal environment. The diversity of corals and the coral coverage was documented to be higher on Mafia compared to most places on Zanzibar by coral reef scientists and the most commonly used tourist guides the pristine marine environment and excellent diving is comparatively more emphasized for Mafia than for Zanzibar.[4]

Coral bleaching and the preferences of reef quality

Coral reefs are highly complex and sensitive ecosystems where seawater temperature is one among many factors affecting their survival and development, but it is considered to be the primary limiting factor (Glynn and Werdt, 1991, Muhando, 2002). The optimum temperature for coral growth (26-28° C) is close to what has been documented as the upper lethal point, about 31-32° C (Jokiel and Coles, 1977). This means that small increases in temperature, especially prolonged exposure will cause stress to the system. In situations of stress the coral releases its photosynthetic pigments, which results in "bleaching" of the corals. Unless the factor causing the stress is removed and the algae can return, the coral dies.

The yearly temperature peak in the seawater outside of Zanzibar is commonly recorded to occur in March –April and it was during this period *El niño* in 1998 hit the area and raised the temperature to a peak of 30.7 (Muhando, 2002). The sea water in the whole Indian Ocean was affected by this increased sea temperature resulting in bleaching and mortality levels from <1% in South Africa to 80% and greater on reefs in Northern Tanzania and Kenya (Obura, 2002) and as much as 95% on many shallow reef tops on the Maldives (Zahir, 2000). The damage varied considerably between reef areas, even when closely situated. Shallow areas were in general more affected due to the combination of higher temperature at the surface and higher exposure to UV radiation. Accordingly would snorkelling activities and glass-bottomed boats be more affected in terms of recreational attractiveness, compared to diving activities.

[3] The average for single-site visitors was 12 days and for multiple-site visitors it was 11 days. The median for both were 7 days.

[4] Based on readings in Footprints East Africa Handbook (1996), The dive sites of Kenya and Tanzania (1997), Lonely Planets guide for East Africa (1997, 2000), Lonely Planets guide for Tanzania, Zanzibar and Pemba (1999).

As pointed out, small or no changes in visitors' behaviour was observed after the bleaching. Given the lumpy and even indivisible character of the good this does not necessarily mean that the individual's utility is not affected by the decreased quality. The stated preference question is designed such that it asks for the individual's welfare measure comparing a visit to the site with or without coral reefs. The reason for selecting the value of access to reefs as opposed to some intermediate quality change was that it turned out to be very complex to assign a quality index to corals. Firstly, coral ecosystems are highly diverse and site-specific, even within a very small area. Secondly, coral is only one attribute contributing to the overall diving experience. Surveys of diving preferences shows that fish is often the most important single attraction of a dive followed by visibility (Andersson, 1997, Cesar *et al.* 2002). Observing diving behaviour or asking stated preference question of the quality of diving is thus likely to include preferences of other attributes besides corals. Fish, at least coral reef fish, indirectly depend on corals but examples are found where other structures such as granite structures in the Seychelles (Cesar *et al,* 2002) and shipwrecks (Wilhelmsson, 1998) are surrounded by a great variety of fish although nearby reefs are destroyed. If the value of corals is measured in isolation embedding bias is then likely to be present. There are also great variations in the awareness of quality changes since to understand and take notice of a changed quality of the underwater environment, knowledge and experience is required. Consequently, an expert might grade an area to be of poor quality while a beginner ranks it high. Table 1 shows how the respondents at the two study sites graded different characteristics before and after the bleaching event, 5 being the highest and 1 the lowest grading[5]. The result does not show any significant change between before and after the bleaching and reef mortality. This is surprising. Equally surprising is that Zanzibar shows a higher aggregate grade, although not significantly so, compared to Mafia in the study before bleaching, which is not in line with biological surveys and guidebooks from this period. The explanation is the low grading for visibility recorded on Mafia. Visibility is seasonal and not an "environmental bad" but, as indicated above, of high significance for a good dive, which further illustrates the complexity of assigning values to a resource which only functions as one of several inputs to an activity. It could also be that the visitors to Zanzibar are less experienced of coral reefs. The average sum of the grading reduced slightly on Zanzibar after the bleaching event but contrary to what one would expect increased for Mafia. In all surveys "fish" scored the highest and it was significantly higher on Mafia. Is this the explanation to the lack of response in visitations to the quality decrease, that it was simply not observed?

CHARACTERISTICS	ZANZIBAR *BEFORE BLEACHING*	ZANZIBAR *AFTER BLAECHING*	MAFIA *BEFORE BLEACHING*	MAFIA *AFTER BLEACHING*
Wilderness feeling	3.20	2.90	3.52	3.40
Fish	3.73	3.56	4.12	4.62
Variety of Coral	3.60	3.44	3.97	3.92
Visibility	3.46	3.27	2.88	3.88
Overall condition of the coral	3.41	3.20	2.86	3.54
Adventurous	2.69	2.40	2.29	2.57
SUM	*20.09*	*18.77*	*19.64*	*21.93*

Table 1 Average grading of different characteristics at the respective site

As mentioned it is difficult to identify quality measures for coral reefs that in turn are useful for policy purposes. It is for example possible to show photos of *before*

[5] The question was posed in the following way*; "How would you grade the conditions of diving/snorkelling here on Zanzibar? Please grade each of the below characteristics on a scale between 1-5. Mark (5) for the best and (1) for the worse."*

and *after* a quality change and ask respondents to state WTP/WTA for the hypothetical change. The question is how the result can be used for policy and applied on a real situation since all reefs look differently and two very closely situated reefs will be differently affected by an external effect. This makes any hypothetical quality indicator difficult to apply even for very local governing. The opportunity to have stated preference data *before* and *after* a quality change is therefore of great value to gain insight of the preferences for coral reefs and changes of their factual quality.

Theoretical Background

Lets assume that the individual decision making process of where to go for holiday involves only one step, *i.e* the individual does not first select a site and then decided what to do while at the site but that the quality and the characteristics of the site is deterministic in the choice of the site. The individual selects holiday resort based on exogenously determined prices to visit the available sites, p_j^i and a variable measuring the quality at these sites, q_j and the individual's income Y^i. If $j = 0,1...n$ indicates all recreational alternatives, including the site of interest for the study, say site z the $j \neq z$ are substitute sites to site z. The utility of visiting the target site z is then $V_z = V(Y^i - p_z^i, q_z)$ and the on-site sample restriction is defined as:

$$V_z \geq \max_{j \neq z}\{V_0, V_1, ...V_n\} \qquad \forall j = 0,1...n \tag{1}$$

Thus, all individuals included in the sample have selected site z because it provides higher utility compared to any other recreational alternative for the given time period.

To estimate recreational welfare measures for the site, the price where the individual is indifferent between going to site z and the next best alternative needs to be captured or estimated. This is the price where:

$$V(Y^i - \tilde{p}_z^i, q_z) = \max_{j \neq z}\{V_0, V_1...V_n\} \quad \forall j = 0,1...n \tag{2}$$

Equation (2) defines the chokeprice $\tilde{p}_z^i$ to visit site z, given that all other variables are unchanged. Next, assume that all trips to site z are identical such that the good being consumed is homogenous, *i.e.* can be defined as "a visit to site z". This means that trips with different lengths of stay are treated as the same good. For this to be a reasonable assumption the standard deviation of number of days at the site has to be low. In addition the marginal cost of an extra day at the site must be low in comparison to the cost of getting to the site which should be true also for the person buying the less expensive trip. Consequently, multi-attraction trips are not included and have to be dealt with differently than described below. To be able to derive welfare estimates an additional restriction on the visitors preferences is invoked, namely weak complementarity *i.e.* that the individual only attaches a value to the quality of the good if consuming it. Lastly, the individual preferences are restricted by defining the good as indivisible in consumption, meaning that the individual only consumes it once or not at all.

Given these assumptions the welfare measure for having access to the site w_a is defined as: [6]

$$w_a = \tilde{p}_z - p_z^{'} \tag{3}$$

which is illustrated in Fig 1. This means that the chokeprice $\tilde{p}_z$ defined in (2)[7], together with the factual price the individual has paid to visit the site $p_z^{'}$, is the only information to be captured or estimated.

To estimate the value of a change in quality at the site the chokeprice of visiting the site given the new quality level also needs to be captured. Assume that the initial quality level $q_z = q_z^0$ deteriorates to a new level $q_z = q_z^1$. Since the chokeprice is a function of quality, a change in quality will result in a shift of the chokeprice. Given the assumptions above, the welfare measure for reefs $w_{quality}$ is then estimated from;

$$w_{quality} = \tilde{p}_z^{q0} - \tilde{p}_z^{q1} \tag{4}$$

This means that the respective choke price before and after the quality change must be captured or estimated.

In the empirical section the w_{access} and $w_{quality}$ in (3) and (4) are captured directly using stated preferences. In the empirical study the q_z^0 indicates the actual and existing quality of the reefs when the individual visits the site and q_z^1 a hypothetical quality level where the reefs at the site are completely degraded. The quality value accordingly measures the value of having access to reefs while visiting the site. The aim in this study is, however, to estimate the value of an intermediate change of the corals, the loss in recreational value caused by coral bleaching. Since the study deals with a factual change in quality and has available the same sort of stated information before and after the change the result of the stated responses, albeit to a different quality change, provides sufficient information to estimate the loss in value caused by bleaching[8]. Lets apply the superscript *no reefs* on the welfare estimate of a quality change due to completely degraded reefs which is the quality change captured in the stated preference question. The questionnaire will then provide stated information of $w_{quality}^{no\ reefs}$ and w_{access} for both t=0 before coral bleaching and t=1 after coral bleaching. Thus, the two surveys contain stated information of;

[6] For further clarifications of how this estimate is derived turn to Andersson (2003).
[7] Hereafter the individual subscript *i* is dropped.
[8] It is uncertain how well a hypothetical stated preference study would be able to directly capture the loss in value caused by bleaching simply because, as discussed above, the bleaching as a quality level is difficult to define. This was the underlying reason of selecting "the value of access to reefs" in the original study.

$$w_{quality}^{no\ reefs\ t=0} = \tilde{p}_z^{\,t=0} - \tilde{p}_z^{no\ reefs} \text{ and } w_{quality}^{no\ reefs\ t=1} = \tilde{p}_z^{t=1} - \tilde{p}_z^{no\ reefs} \quad (5)$$

and similarly;

$$w_{access}^{t=0} = \tilde{p}_z^{t=0} - p_z^{'} \text{ and } w_{access}^{t=1} = \tilde{p}_z^{t=1} - p_z^{'} \quad (6)$$

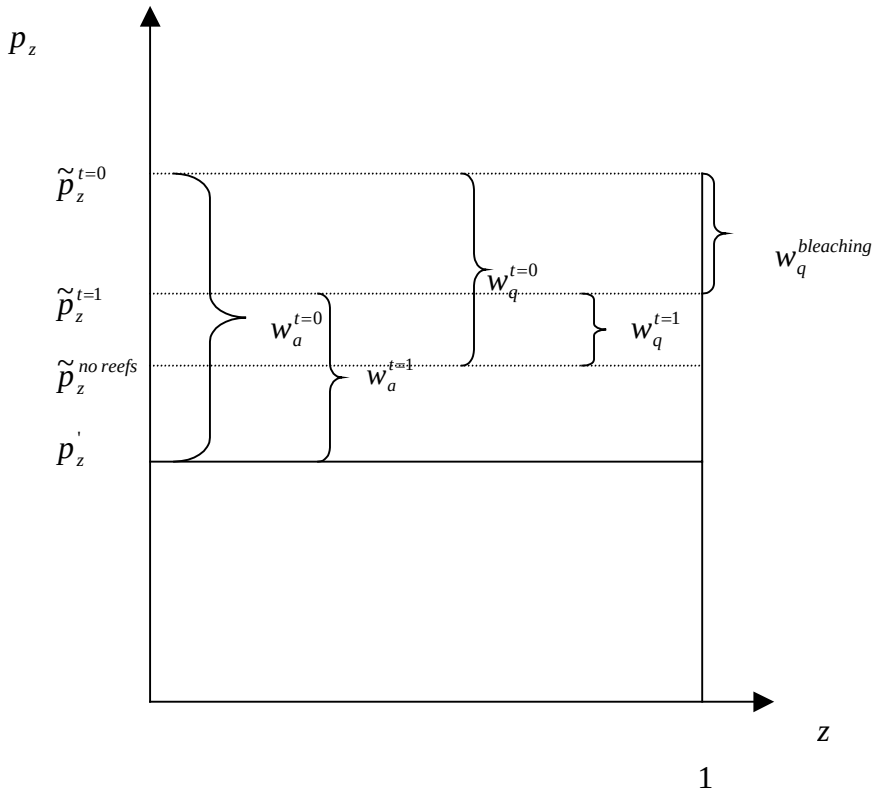


Figure 1. Demand for access to a site with indivisibility in consumption illustrating how the welfare estimates from the stated preference questions are derived.

The equations are illustrated in Figure 1. Apply the assumption of identical preferences of the individuals in the sample for both periods and assume that all other variables including the actual cost of visiting site z remain unchanged or are adjusted for between the same time periods. Then;

$$w_{quality}^{bleaching} = w_{quality}^{no\ reefs\ t=0} - w_{quality}^{no\ reefs\ t=1} = w_{access}^{t=0} - w_{access}^{t=1} = \tilde{p}_z^{t=0} - \tilde{p}_z^{t=1} \quad (7)$$

where $w_{quality}^{bleaching}$ is the loss in value due to bleaching. The result in equation (7) is illustrated in Figure 1. Accordingly, by simply subtracting the respective measure of the stated preference questions for the two time-periods the loss in value from bleaching is estimated. And the result, as equation (7) shows, should in theory result in the same measure for both questions. From the result in (7) it is also easy to see that revealed preference can be applied since $w_{quality}^{bleaching} = \widetilde{p}_z^{t=0} - \widetilde{p}_z^{t=1}$ and the chokeprices for the respective time period can be estimated given only information of the factual prices of visiting the site.

Method

Study format

The design of the original questionnaire was initiated by a pilot test, undertaken in both Zanzibar and Mafia in March 1996 followed by a seminar, attended by both economists and ecologists resulting in modifications of the order, content and formulation of the questions. The first survey was carried out during peak tourist season in December-January and in low season January-February 1997. The follow up study was administered in peak season in August 1999 and in low season September, October the same year. The fact the respective studies were administered at different times of the year resulted in that a smaller number of backpackers were included in the second sample compared to the first since those mainly travel during the winter period in the northern hemisphere. The bleaching took place in spring 1998 and it was expected that by the time of administering the second survey visitors would respond to the degraded reefs. The questionnaire was distributed in both English and Italian[9].

A selection of dive sites typically visited by different groups of representative travelers was made. On Zanzibar, the town area, a predominately backpacker area and an area mainly occupied by luxury hotels were covered. The follow up study covered the luxury hotels to a lesser extent. A random selection of dive trips at the respective sites and dive operators was then drawn. In addition individuals at the beach and hotel areas were approached as to also cover individuals who only snorkeled[10]. On Mafia, which is considerably smaller, all hotels providing dive operations were covered. At the time of both surveys diving and snorkeling were the only reef related recreational activities in the area. Glass bottomed boats did not exist.

Altogether seven dive operators out of the ten then existing were covered on Zanzibar. At the time of the first survey only one dive business operated on Mafia where there were normally two. The questionnaires were handed over to the respondents to fill in on their own but there was always a person available to assist. There might be a bias in the sense that the clients staying in the most luxurious hotels were under represented due to reluctance among hotel operators to have interviews taking place in those hotel areas. In the second survey the interviewer was of local origin and had great difficulty in entering into some of the self-contained luxury hotels.

[9] The pilot study showed that the only nationality having difficulties with English were the Italians who in addition constituted a large proportion of the total number of tourists visiting the islands. In average 25% of the total number of international tourist arrivals were Italians (Commission for Tourism, Zanzibar).

[10] Although, snorkelers often used the dive boats to access the reefs, which means that, they were automatically included at the dive operations as well.

Question format

The respondents were asked to state their actual cost of travelling to the site, the cost of accommodation and lastly how much they spent on food and contingencies during the visit. In the pilot study it was noted that while some individuals exclusively visited the study site others were on a multi-site trip. Hence, a section was added to capture the overall costs paid by the multi-site visitors. The individuals on a multi-site trip were requested to state their cost of travel, accommodation and contingencies for the entire trip as well as for the trip to Zanzibar/Mafia. Additional information about multi-site visitors was collected, including the sites they had/intended to visit and if they dived in other places while on the trip.

To capture the value for access the individuals were asked to state their WTP equal to w_{access} in equation (3) directly, by posing the following open ended question; *"Considering your experience so far on this trip to Zanzibar, and the total cost of this trip (as stated in question 18) ; How much more expensive would your trip have to be before you decide to not come to the site?"*. This question was immediately followed by the following question *If the reefs on Zanzibar were completely degraded how much cheaper would your trip have to be for you to still come to Zanzibar?"* Where the latter asks the respondent to state the WTA compensation for a visit to the site in a situation of completely destroyed reefs, equal to $w_{quality}$ in equation (4). As discussed, it is complex to assign quality measures for coral ecosystems and therefore the measure of "with or without" corals at the site was selected. The first study was carried out without knowing that within a few years' coral bleaching would hit the area.

In addition, other relevant socio-economic information, traveling habits (during the actual trip and in the past), diving profile and perceptions about the reefs and the dives were collected for each respondent. In the second survey, questions about coral bleaching were added at the end of the survey. The respondents were asked about their knowledge of coral bleaching in general, if they had seen any bleaching while diving at the site and if the information that a site was affected by bleaching would effect their choice of holiday destination.

Discussion of the question format

The two stated preference questions are similar in that they are open-ended, use the cost of the trip as a payment vehicle and they both derive a compensated variation (CV) estimate but they differ in that the w_{access} estimate is the result of a WTP question and the $w_{quality}$ of a WTA question. The reason for designing the questions interchangeably in a WTP /WTA format and not selecting either was that it was considered the most natural way of formulating the question to receive the most reliable responses. Another issue is that the stated questions are open-ended, a question format that has been debated in the literature[11]. The main argument in favour for open-ended questions here is that they provide more information than any discrete choice question[12]. The argument that open-ended questions provide a less familiar purchase scenario for the respondent was not the empirical experience in the study, maybe because the cost of

[11] The NOAA panel (Arrow et al. 1993) as well as many CV practitioners share the view that closed-ended question formats are superior to an open-ended approach. The most common argument is that discrete choice situation is more similar to a traditional market situation where it would be easier for a respondent to compare two utility levels as opposed to stating the single largest amount of money equalling these two utilities.

[12] Readers interested in the subject see for example Ready et. al. (2001),Welsh and Poe (1998), Carson et. al. (1997), Brown et al (1996), Gregory et. al. (1995)

the trip was used as a payment vehicle which meant that the choice situation, the good and the mode of payment were all familiar to the respondents.

Under common circumstances a WTP value is restricted by the individuals budget while the WTA is not bounded. The fact that the cost of travelling is used as a payment vehicle and that quality deteriorates in this case, however, implies that there is an upper bound on the WTA response. The upper bound is the stated chokeprice for access. The reason for this is that it is the *use value* that is being estimated. The respondents state their WTP for the use of the site and the WTA for the loss of quality only in the case of using it and not for any possible non-use values attached to the site. Sometimes the individuals state a WTA value that is below the factual price indicated as the shaded area in Figure 2. In such a situation where $\tilde{p}_z^{no\ reefs} < p_z^{'}$, the individual would exit the market and not come to the site and the welfare estimate is zero. This accrues to the assumption of weak complementarity which means that $\tilde{p}_z - p_z^{'}$ cannot be smaller than $\tilde{p}_z - \tilde{p}_z^{no\ reefs}$ and therefore $\tilde{p}_z - p_z^{'}$ becomes the upper bound for the WTA response. In situations where $\tilde{p}_z^{no\ reefs} < p_z^{'}$ this is corrected for such that if $\tilde{p}_z - p_z^{'} < \tilde{p}_z - \tilde{p}_z^{no\ reefs}$ then $w_{access} = w_{quality}$. The result of the stated $w_{quality}$ is however included in the preceding estimations as a way to observe difference in the respective values and their respective consistency with theory. In the proceeding text, the stated response is denoted $w_{quality}^{no\ reefs}$ and the estimate that has been adjusted for by the weak complimentarity assumption is denoted $w_{quality}^{constrained.}$. The difference is the shaded area in Figure 2.

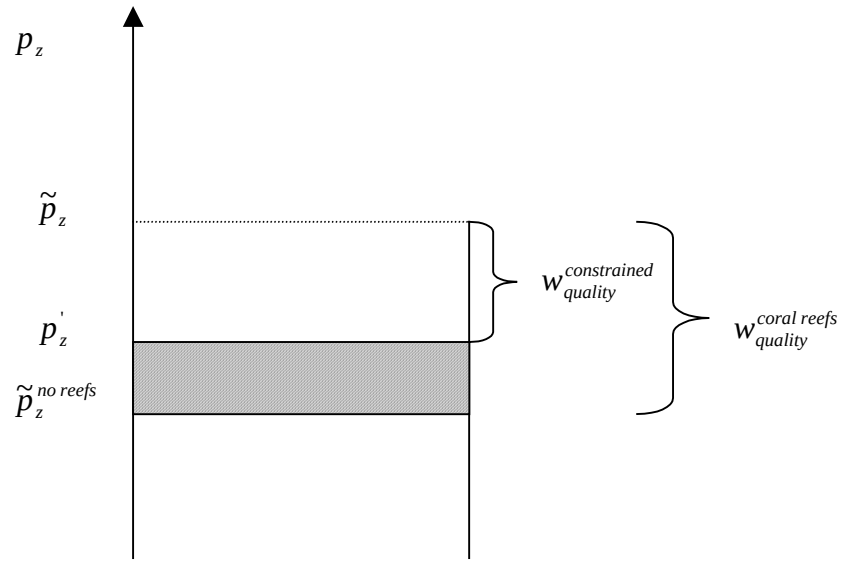


Figure 2. Indicating the difference between the $w_{quality}^{no\ reefs}$ and the $w_{quality}^{constrained.}$ estimates.

The risk for mis-specification bias is considered smaller for on-site surveys (Whitehead *et.al.* 1995). Most individuals in the sample had previous experience of coral reefs[13]which would supposedly improve the accuracy of the CVM responses. The familiar payment situation of using the cost of the trip as a payment vehicle is also

[13] The respondent in Zanzibar had in average conducted 71 earlier dives and the respondents on Mafia in average 186 dives. The majority of these were undertaken in tropical waters with coral reefs.

expected to have a positive impact on the accuracy. To reduce the risk for strategic bias the respondents were informed that the University, which is supposedly seen as a neutral institution, conducted the survey.

As mentioned above it is implicitly assumed that the reference level in the open-ended questions is at home since this seems to be the most plausible decision place. This is not explicitly stated in the question and in a repetition of the study the CVM questions could start with a sentence; …*imagine that you are at home and about to select which site to visit*… Given the assumption that the reference utility is at home the compensated variation equals the behaviour based welfare estimate derived from the choke price defined in equation (2)[14].

Result

Sample description

The response rate, in terms of people willing to fill in the questionnaire, was as high as 95%[15] in both time-periods. This is probably due to the fact that divers and people snorkelling in general are interested in the marine environment[16], and are accordingly willing to support attempts to improve its management. In total, 552 tourists were interviewed on Zanzibar and 71 on Mafia. Respondents who were either resident, worked at the site, were below 18 years of age or provided inconsistent information were deleted from the sample. In instances where the interviewed individuals belonged to the same household they were treated as separate observations. This was considered appropriate since it was observed that the majority travelled on their own budget[17]. The final sample consisted of 510 individuals for Zanzibar and 61 individuals for Mafia[18]. These figures represent about 1.4/0.75 % of the total international arrivals in Zanzibar and about 7.1/3.5 % of total number of tourists on Mafia during the surveyed time-period[19]. For those the response rate *on the CVM questions* were 80/70% on Zanzibar and 81/85% on Mafia.

Descriptive statistics for the samples are shown in Table 2. Differences between the respective samples are found between the two sites rather than between the different time periods. Since a necessary assumption is that the individuals have identical preferences in the two time periods this facilitates the estimations. The changes that are observed between the two time periods are mainly related to the diving and snorkelling behaviour. A measure of the intensity of "reef consumption" was constructed by assuming that two dives or two hours snorkelling represented a full day's "reef consumption". The number of days of "reef-consumption" was then divided by the number of days the individual stayed at the site. This value increased significantly on

[14] See Andersson (2003) for further explanations of this.

[15] This figure refers to the percentage of individuals who accepted to fill in the questionnaire when being approached and asked to do so.

[16] This was confirmed in the questionnaire. In average 85 % stated that they were "interested" or "very interested" in the marine environment for all samples.

[17] This might be because the average age was relatively low. Exceptions were some elderly couples where the woman had a comparatively low or no income.

[18] Among those 322 individuals were interviewed in Zanzibar 1996/97 and 188 individuals in 1999. and 37 individuals were sampled in 1996/97 on Mafia and 24 individuals 1999.

[19] Numbers of Total arrivals to Zanzibar were acquired from Commission for Tourism and for Mafia from Hotel statistics. According to these sources about 23 000 international visitors arrived in Zanzibar from 1 Dec 96- 1 March 97 and 25 000 from 1 August-31 October. Approximately 520 and 690 arrived to Mafia during the same periods. These are, however, total arrivals while as the sample selection criterion was people who dived or snorkelled. There is no available statistics of the proportion of people diving or snorkelling among the total number of arrivals.

Mafia after bleaching while it instead decreased somewhat on Zanzibar. In terms of type of reef consumption both diving and snorkelling decreased on Zanzibar but on Mafia diving increased while snorkelling decreased. That snorkelling decreased is in line with the fact that bleaching hit shallow areas harder. The experience of diving, expressed in the number of earlier dives the individual had acquired, was considerably higher for Mafia compared to Zanzibar in the study before bleaching. After the bleaching more experienced divers continued to come to Mafia but not to Zanzibar. The Mafia visitors spent in average double as much money on diving or snorkelling and the figure increased on Mafia while it remained the same on Zanzibar[20]. The fact that changes mainly had to do with people's behaviour related to reef consumption means that it might be an endogenous effect triggered by the bleaching. The type of visitors differed, however between the two sites. The average age and annual income were higher on Mafia and the visitors stayed in average twice as many days in Zanzibar compared to Mafia. That individuals stayed longer in Zanzibar is probably because Zanzibar offers more additional attractions compared to Mafia. The result from the sample seems to indicate that Mafia is profiled towards a more specialised form of diving tourism.

Variable	Description	Mean Zan 1996/97	Zan 1999	Mafia 1996/97	Mafia 1999
INCOME	1=1_below 15´',2=15'-30',3=30'-45', 4=45'-60', 5=60'-75', 6=75'-90', 7=90'-105', 8=above 105'	2.8 (1.73)	3.0 (1.88)	4.0 (2.12)	4.5 (2.2)
FEMALE	1=female, 0=male	0.43 (0.5)	0.47 (0.5)	0.46 (0.51)	0.38 (0.49)
AGE	Age in years	30 (7.1)	29 (6.8)	39 (11.8)	40 (9.5)
EDU-CATION	1=Junior Sch., 2=High Sch.,3=BA, 4=M.SC, 4=Ph.D	3.01 (0.88)	3.13 (0.86)	2.89 (0.81)	3.0 (1.1)
IMPCORAL	Prop. "reef consumption" during trip to Z/M	0.35 (0.25)	0.32 (0.24)	0.59 (0.35)	0.86 (0.36)
MARINE INTEREST	1=Not interested, 2=Passive interest, 3=Interested, 4=Very interested	3.24 (0.72)	3.14 (0.69)	3.27 (0.73)	3.29 (0.69)
DAYS Z/M	Number of days spent in Zanzibar/Mafia	12 (7.4)	11 (11.6)	5 (3.01)	6 (3.5)
DIVE Z/M	Number of dives while on Zanzibar/Mafia	5.4 (5.6)	3.0 (3.32)	2.6 (3.7)	5.8 (3.87)
HRSSNOR	Hours snorkelled while on Zanzibar/Mafia	5.0 (6.6)	3.0 (5.38)	3.6 (3.8)	3.3 (2.8)
TOTDAYS	Total number of days when on a multi-attraction trip	72 (72)	44 (39.5)	20 (6.76)	34 (41)
PARTTRIP	1=Part of a larger trip 0=Only visit Z/M	0.49 (0.5)	0.75 (0.44)	0.49 (0.51)	0.67 (0.48)
PROP Z/M	Proportion of multi-site trip spent on Z/M	0.26 (0.18)	0.29 (0.17)	0.63 (0.39)	0.51 (0.37)
COSTDIV	Total cost spent on diving in USD	153 (199)	143 (148)	161 (263)	286 (245)
Z/M TC	Travel cost to Z/M in USD	513 (623)	337 (351)	551 (822)	564 (1092)
Z/M DAY COST	Total cost on trip to Z/M/number of days at site	103 (105)	92 (78)	256 (253)	238 (238)
EARLIER[21] DIVES	Total number of dives the individual had conducted before	49 (99)	31 (44)	85 (121)	92 (120)

Table 2. Descriptive statistics of the four samples showing the mean of the independent variables.

[20] The average daily cost spent on diving in Mafia was 33 USD (46) in 1996/97, which increased to 45 USD (21) in 1999. In Zanzibar the equivalent was 14 USD per day (15) in 1996/97, which increased slightly to 16 (17) in 1999. Numbers in brackets indicate standard deviation.

[21] The averages were estimated only for divers *i.e* not for people whom snorkelled. Extreme outliers of individuals who had conducted above 1000 dives were deleted.

The origin of the visitors was scattered all over the world with a large majority originating from Europe followed by South Africans and expatriates from other African countries. A smaller portion came from North America and Australia[22]. A difference was observed between peak and low season where visitors from adjacent African countries dominated in high season while backpackers type visitors from Europe more frequently travelled in low season. This meant that for the combined sample as many as 98% were from a developed country. Interviews with dive operators confirmed that diving and snorkelling was an activity exclusively carried out by tourists or temporary residents originating from foreign countries. In similar studies of game parks and other typical international tourist attractions, nationals often participate to a significant portion in the recreational activities[23], but it was not the case for coral related recreational activities. The distribution of nationalities did according to official statistics for Zanzibar change between the two time periods but the samples did not represent this change. The number of Italian visitors increased by 40% between t=0 and t=1 resulting in that Italians constituted about 27% of total arrivals to Zanzibar. The 1999 sample did not have one single observation of Italians[24]. To test if this had a large effect on the sample a comparison was made by excluding the Italians in the 96/97 sample, but this did not result in any significant changes in the descriptive statistics.

In the 96/97 surveys about 50% of the visitors at both sites were on a multi-site, tour in the EA region. In the 1999 survey this had increased to 74 % on Zanzibar and 66 % on Mafia. The most common additional attraction on multi-attraction trips was to visit game-parks in the northern circuit and to climb Mount Kilimanjaro. Among the multi-site visitors 40% in the Zanzibar sample had also dived in other areas on the trip, the most commonly stated place was Lake Malawi that provided inexpensive dive certificates. The multi-site visitors from the Zanzibar 96/97 sample stayed in East Africa for an average of 2,5 months while the multi-site visitors in the Mafia sample stayed on average 20 days. In the 1999 sample the long-term backpackers were fewer and the average number of days the multi-site visitors stayed in the region decreased considerably for the Zanzibar sample while it increased slightly for Mafia. The proportion of the overall trip that the multi-site visitors stayed in Zanzibar/Mafia however, remained the same for Zanzibar while is decreased for Mafia.

Regarding the open question of substitute sites to Zanzibar/Mafia, the respondents stated typical diving areas, although they were not specifically requested to state dive sites, from all over the world. Table 3 summaries the result. The dive sites that were mentioned had been affected by the bleaching in 1998 to varying degrees. For example, South Africa was not significantly affected while the Maldives was severely affected.

Among the Mafia visitors a large portion mentioned Zanzibar as a substitute site but not the opposite. In Zanzibar 91% from the sample visited Zanzibar for the first time and the equivalent for Mafia was 87%. The number that visited Zanzibar/Mafia for the first time decreased somewhat in the second survey. Among those who had visited the site earlier the majority were temporary residents in Tanzania, often residing in Dar es Salaam, which is the closest situated city for both islands.

[22] See Table 3.
[23] See, for example, Navrud and Mungatana (1994) and Dave and Mendelson (1991).
[24] The main reason for this was the difficulty of entering into these hotel areas since they were reluctant of letting local people enter.

"Zone"	Substitute site	Mafia (%)	Zanzibar (%)
Closely situated islands and coastal areas. Substitute alternative for multi-site visitors	Mafia	----------	7
	Zanzibar	36	---------
	Pemba	12	4
	Tanzania Mainland	0	2
	Kenya Coast	8	14
Island states and coastal areas in the West Indian Ocean. Substitute alternatives for single-site visitors	Mauritius	0	2
	Seychelles	8	7
	Madagascar	4	4
	Mozambique	12	4
	Comoros Islands	0	2
	South Africa	0	3
Other Continents Substitute alternatives for single-site visitors	Red Sea	4	7
	Maldives	0	15
	Thailand	0	5
	Great Barrier Reef	4	7
	Caribbean	4	11
	Micro- and Polynesia	8	6
SUM		100%	100%

Table 3 List of substitute sites stated by the respondents in an open question

Welfare Results

Stated Preferences

The average and median results of the responses to the open-ended questions of WTP for access (w_{access}) and WTA compensation for loss of access to reefs the ($w_{quality}$) are shown in Table 4[25]. A general observation from simply looking at the numbers is that they confirm what the sample description indicated and what guidebooks and biologist alike maintain, namely that the reefs on Mafia were of better quality and played a larger role for the overall utility of the trip compared to the reefs on Zanzibar. The value of access to Mafia as a site is similar to that of Zanzibar but the value of access to reefs while at the site is considerably higher for Mafia compared to Zanzibar. This is when observing the result of the average values. Surprisingly the WTA question on Zanzibar showed a high frequency of zeros, especially in the 1996/97 sample. This gives reason to suspect protest answers. What does a zero response represent in the respective question? For the w_{access} question the zeros implies that the individuals actual price is above or equal to the chokeprice *i.e.* $p_z^{'} \geq \tilde{p}_z$, it is, however unknown if it is above or equal. In the case of the $w_{quality}$ estimate, a zero response means that $\tilde{p}_z = \tilde{p}_z^{no\ reefs}$ and the individual place no value on the existence of reefs while visiting the site. This explains why there are no zero responses on Mafia given that the reefs are a major reason for going there. Since the $w_{quality}^{constrained}$ estimate carries the zeros from both the w_{access} and $w_{quality}$ estimates[26] the difference in the result of including zeros or not is more extreme for Zanzibar carrying many more zero answers.

The two samples from the same site but from the different time periods were merged, *i.e* Zanzibar 1996/97 and Zanzibar 1999 were combined in one sample and similarly for Mafia. A dummy for before and after bleaching was created and given the high frequency of zero responses a Probit for individuals with either zero or positive response and a Truncated Regression for respondents with w_{access} / $w_{quality}$ >0 was run[27].

[25] Prices and costs are deflated to 1997 (January) USD.

[26] This is because if $w_{access} = 0$ then $w_a = w_{quality}^{constrained} = 0$ and if $w_{quality}^{no\ reef} = 0$ then $w_{quality}^{no\ reef} = w_{quality}^{constrained} = 0$.

[27] A selection model (Tobit type 2) was tested but the lambda was not significant.

This implies that the sample is treated as if it is from a truncated distribution with a truncation level at zero. Explanatory variables for the w_{access} estimate were income, gender, education, the proportion of the total trip spent on Zanzibar/Mafia (PropZ/M)[28], the dummy for bleaching and the average cost spent per day while at the site (Daycost Z/M). The latter variable was included to capture different tourist segments (low, medium, high budget). When testing for correlation between the variables, age and income were correlated[29] and to avoid correlation in the regression age was dropped. Explanatory variables for the $w_{quality}$ estimate included the same socio-economic variables, the cost spent on the diving or snorkelling while at the site (costdiv), the intensity of coral consumption during the holiday (impcoral) and a variable indicating how the individual graded the quality of the dive at the site (quality) and bleaching. The variable of daily cost was removed. The results of the parameter estimates are displayed in Appendix A showing the marginal effects.

	w_{access} (incl. zeros)	w_{access} (excl. zeros)	$w_{quality}$ (incl zeros)	$w_{quality}$ (excl. zeros)	$w_{quality}^{constrained}$ (incl zeros)	$w_{quality}^{constrained}$ (excl. zeros)
Zanzibar 1996/97, t=0						
Average value (USD)	470	570	420	555	246	376
% zeros(of total nr. of resp)	18 %	------	24%	------	35%	-----
(standard deviation)	(650)	(675)	(600)	(630)	(366)	(395)
MEDIAN	200	300	225	300	0	100
Number of respondents	257	211	250	190	250	162
Zanzibar 1999, t=1						
Average value (USD)	440	530	410	480	248	330
% zeros (of total nr. of resp)	17%	-----	14%	-----	25%	-----
(standard deviation)	(645)	(670)	(500)	(510)	(385)	(412)
MEDIAN	200	300	275	340	0	100
Number of respondents	135	112	128	110	128	96
Mafia 1996/97[30], t=0						
Average value (USD)	400	540	1090	1120	376	546
% zeros (of total nr. of resp)	27 %	------	3%	------	31%	-----
(standard deviation)	(920)	(1040)	(1010)	(1010)	(929)	(1084)
MEDIAN	160	250	300	300	0	300
Number of respondents	30	22	30	29	30	21
Mafia 1999, t=1						
Average value (USD)	370	480	1040	1040	261	348
% zeros (of total nr. of resp)	20%	------	0%	-----	25%	-----
(standard deviation)	(500)	(520)	(1650)	(1650)	(345)	(357)
MEDIAN	0	400	250	250	0	200
Number of respondents	21	17	20	20	20	15

w_{access} = WTP for access to the respective site

$w_{quality}$ WTA compensation for completely degraded reefs at the respective site

$w_{quality}^{constrained} = w_{quality}$ has been adjusted for the weak complementarity assumption, *i.e* when $\tilde{p}_z - p_z^{'} < \tilde{p}_z - \tilde{p}_z^{no\ reefs}$ which means tat $w_{access} = w_{quality}$.

Table 4. The average values of the stated answers to the respective welfare estimates for all samples.

Since the issue of interest is to assess the change in visitor's welfare due to the bleaching effect, the bleaching dummy was closely assessed. The dummy indicates if

[28] If the individual is not on a multi-site tour and only visits Zanzibar or Mafia this variable equals 1.
[29] Zanzibar 96/97, 0.406, Zanzibar 99, 0.493, Mafia 96, 0.2341, Mafia 0.446.
[30] In this sample an extreme outlier was reduced to not distort the result of the sample too much. The individual was a very wealthy individual who indicated a w_q of 12 400 USD.

there had been any change in the w_{access} and $w_{quality}$ response between before and after the bleaching. This is summarized in Table 5. for the respective model and site. The Probit model shows positive values except for access to Zanzibar but only $w_{quality}$ on Zanzibar is significant. A positive sign means that visitors would be less likely to have zero w_{access} / $w_{quality}$ after the bleaching. For the truncated model the different samples show different signs. The w_{access} estimate for Zanzibar shows a negative sign and it is highly significant. The interpretation is that a person is willing to pay about 300 USD less for access to Zanzibar after the bleaching of the reefs. The willingness to accept compensation for the reefs on Zanzibar is positive but not significant and this is the same for the constrained estimate. For Mafia all relative values for bleaching are negative and significant especially for the reefs. The WTP for access to Mafia is reduced by 110 USD after the bleaching and the willingness to accept compensation by 555 USD or 255 USD for the constrained estimate.

	Probit (where w>0=1)			Truncated Regression (on w>0)		
	Coefficient bleaching dummy (p-value)	Likelihood Ratio Test for pooling (cr. v. at 0.95)	P-value 1-CHI(ratio,2)	Coefficient bleaching dummy (p-value)	Likelihood Ratio for pooling (cr. v at 0.95)	P-value 1-CHI(ratio,2)
Zanzibar w_{access}	-0.096 (0.104)	6.628 (11.07)	.24982	-308 (0.002)	-14.91 (11.07)	
Zanzibar $w_{quality}$	0.142 (0.0048)	12.4201 (12.59)	.02946	59.19 (0.4393)	9.498 (12.59)	.1474
Zanzibar $w_{quality}^{constrained}$	0.053 (0.4707)	9.39170 (12.59)	.15272	87 (0.1772)	11.11 (12.59)	.08509
Mafia w_{access}	0.039 (0.77)	-37.90 (11.07)		-111 (0.19)	17.96 (11.07)	.002993
Mafia $w_{quality}$	-------	--------	----------	-555 (0.011)	19.573 (12.59)	.05978
Mafia $w_{quality}^{constrained}$	0.078 (0.683)	13.29 (12.59)	.03863	-255 (0.005)	48.96 (12.59)	.7599 D-08

Table 5. The relative values of the dummy for bleaching in the merged samples (*p*-values in brackets). Before bleaching =0, after bleaching=1. A Likelihood Ratio Test is run testing the hypothesis that the two samples from the two different time-periods have the same coefficient.

A likelihood ratio test for pooling was applied to test whether it is reasonable to merge the two samples and treat them as having the same coefficients.[31] The result is shown in Table 5 together with the respective p-values. The following hypothesis was tested; H0: The same model applies to both samples, H1: The form of the model is the same for both groups but the parameters differ between the two samples. The result is mixed. The hypothesis that the two samples from the different time period have the same coefficients is accepted for Zanzibar responses but not for Mafia where the null hypothesis is rejected. The Mafia result should be considered with caution and the decreased welfare measure due to bleaching might instead be explained by a shift in

[31] Likelihood ratio test= -2*(L1-L2-L3) where L1=Likelihood Ratio for the merged sample, L2= Likelihood Ratio for the 1996/97 sample and L3= Likelihood Ratio for the 1998 sample.

tourist segment, *i.e.* the assumption of identical preferences in the two periods does not hold. The fact that the Mafia result is less significant might be explained by the smaller sample size on Mafia.

Next the change in welfare between the two time periods is estimated by subtracting the respective estimates as in equation (7). The result is shown in Table 5. As discussed, it is uncertain how the fact that the w_{access} and $w_{quality}$ estimates are derived interchangeably from a WTP and a WTA question will empirically affect the $w_q^{bleaching}$ value. From the result it seems as the WTA derived estimates *i.e.* the $w_{quality}$ estimate result in larger values which would suggest that the increment in quality has a relative effect on the WTP/WTA ratio. This is when using the estimate excluding the zeros.

	$w_{access}^{t=0} - w_{access}^{t=1}$		$w_{quality}^{noreefs,\ t=0} - w_{quality}^{noreefs,\ t=1}$		$w_{quality}^{constr,t=0} - w_{quality}^{constr,t=1}$	
	incl. zeros	excl. zeros	incl. zeros	excl. zeros	incl. zeros	excl. zeros
Zanzibar $w_q^{bleaching}$	30	40	10	75	0	50
Value of test function[1] (critical value 10%; 1.284)	*0.435*	*0.508*	*0.291*	*1.063*	*0*	*0.967*
Mafia $w_q^{bleaching}$	30	60	50	80	115	200
Value of test function (critical value 10%; 1.284)	*0.1358*	*0.217*	*0.133*	*0.211*	*0.528*	*0.686*

1.

$$t = \frac{Average\ \ value_{96/97} - Average\ \ value_{99}}{\sqrt{s_p^2\left(\frac{1}{n_{96/97}} + \frac{1}{n_{99}}\right)}}$$

$$s_p^2 = \frac{(n_{96/97} - 1)(stdv_{96/97})^2 + (n_{99} - 1)(stdv_{99})^2}{n_{96/97} + n_{99} - 2}$$

Table 6. The estimated recreational loss of value due coral bleaching, $w_q^{bleaching}$ using equation (7).

The average estimates for the value of access and loss of reefs are attached with very high standard deviations (which is normal since the questions are open-ended) and when applying a t-test none of the differences between the means of the two periods are statistically different. The result of the test function is shown in Table 6 where HO: $Mean_{96/97} - Mean_{99} = 0$ and H1: $Mean_{96/97} - Mean_{99} \neq 0$ are tested. The null hypothesis is accepted for all samples, which means that the decrease in welfare estimates after the bleaching event is not statistically significant and the loss of recreational value zero. It is accordingly not possible to, based on the stated preference question and the assumptions attached to the model, conclude that the bleaching has caused loss in welfare for the visitors.

Revealed preferences

To apply the revealed preference method the choke price as defined in equation (2) needs to be captured for the two time periods. The first and rather problematic issue is, however, to derive the factual cost of the trip *i.e.* $p_z^{'}$. The reason is that about half of the individuals in the samples in t=0 were on a multi-site trip and even more in t=1. In the stated preference case this was not needed since the welfare estimate was derived directly. The questionnaire was designed in such a way that the individuals

on a multi-site trip themselves would indicate the share of the cost of the total trip that accrued to the trip to Zanzibar. Unfortunately, this stated amount was often the factual cost of getting to the island *e.g.* taking the ferry from Dar es Salaam. This was not very useful in terms of reflecting the revealed preferences of visiting Zanzibar/Mafia as part of the multi-site trip, since logically a share of the overall cost of getting to the area should be included. Among the multi-site visitors two distinct sub-groups were observed. One group stayed from two months up to a year living on a low budget travelling around in East Africa. This sorts of travellers often included Zanzibar on their multi-site trip but rarely Mafia. The other sub-group consisted of visitors who travelled in the area between two and four weeks staying in the more expensive resorts. Consequently, the average number of days the multi-site visitors in the Zanzibar sample stayed in the region was two and a half months with a median of 30 days. Due to the great variation in multi-site visitor's *relative* stay in Zanzibar/Mafia on their whole trip in East Africa and the fact that there is no obvious way to divide these visitors expenses between different sites, some assumptions were invoked. The low budget multi-site visitors were treated as "residents". The travel cost for this group was the cost of visiting Zanzibar/Mafia that they had indicated in the questionnaire. The "population" of this group was then the total number of tourist entering the region. The luxury multi-site travellers cost was approximated to the cost paid by the single site visitors originating from the same country.

Region	Pop.(millions)[1]	Nr. Visitors[2]		Nr. of visitors in the sample		Average cost[3] (USD)		Median cost (USD)		Pr(visit) (in 10 000)	
		1997	1999	1997	1999	1997	1999	1997	1999	1997	1999
Scandinavia	24	7 320	7 011	68	16	1550	820	1000	820	30,54	29,2
Germany	82	5 472	4 618	29	14	1030	920	950	900	6,67	5,6
UK	59	13 396	14 141	44	62	2200	730	1750	800	22,71	24,0
Italy[3]	57	16 542	23 279	19	0	710	650	600	650	29,12	41,0
Other EU[4]	153	12 277	13 310	21	40	920	910	900	1000	8,03	8,71
USA, CAN	301	6 642	6 745	18	19	2000	2000	2000	2000	2,21	2,24
Kenya[5]	3	4 924	2 790	1	3	250	345	250	300	175,86	99,6
Other Africa[6]	6	4 157	2 675	15	3	760	270	600	300	75,58	48,6
RSA[7]	13	2 664	902	48	4	640	650	600	600	20,75	7,02
AUS/NZ	22	5 206	6 324	1	19	780	700	780	700	23,45	28,5
Tanzania[8]	2	4 000	4000	14	0	146	150	68	100	200	200

1 Source Fakta kalender 2000.
2 Source Zanzibar Commission for Tourism.
3 In cases where very few or no observations are available approximations of the costs are made based on market prices of travelling from that country
4 Other European countries include The Netherlands (15,7m), Belgium (10,2m), Ireland (3,6m), Switzerland (7,3m), Spain (39,1m), Portugal (9,9m), Austria (8,1m) and France (59m).
5 Including an estimate for the 700 000 yearly visitors to Kenya (WDI, 1999)
6 Other African countries include: Uganda (22.2m) Namibia (1.6 m) Zambia (9.5m) Zimbabwe (11m) Swaziland (0.966m) Malawi (9.8m) Botswana (1.4m). It is assumed that 10 % of the total population in "Other Africa" are expatriates or has an income permitting them to undertake these sorts of trips.
7 For RSA it is assumed that 30% of the population is able to buy this sort of trip.
8 Including an estimate for the 350 000 yearly visitors to Tanzania (WDI, 1999)

Table 7 List of zones, their respective population and average and median cost of travelling to Zanzibar from each zone.

The cost of travelling from different countries was regressed against the probability that individuals originating from that country would visit the site. The cost of travelling from a specific country was estimated from the average and median cost paid by the individuals in the sample originating from that country. For some countries the individual variability in the price of the trip were small while others had substantial

differences[32]. The sample for Mafia was too small to provide reliable estimates and was excluded from this exercise. For the measure of the probability to visit Zanzibar, official statistics of yearly numbers of visitors from different countries in the world was used[33]. The "zoning" was adapted to this statistics. The number of yearly visitors was then divided by the population of that country or that region, measuring the probability of a visit from that zone *Pr(visit)*. Since the study showed that only visitors with a nationality of developed countries participated in the recreation activity, an approximation of the number of expatriates in the African region was made. Table 7 summaries the results.

An OLS regression was run with the probability of visiting the site as the dependent variable and the cost of visiting p_z as the explanatory variable, *i.e.* $\Pr(visit) = \alpha + \beta p_z$, where the *Pr(visit)* equals the number of visitors from a certain region divided by the population of that region. The regression was run for both the average and the median values of the $p_z^{'}$ (see Table 6). The result shows correct signs and significant estimate for both the average value and the median value, (the output is displayed in Appendix B).

To estimate the aggregate consumer surplus (CS) value[34] identical preferences for all individuals, and identical incomes was assumed together with the assumption that all other variables had remained unchanged. By subtracting the estimates for the respective time periods the annual loss due to coral bleaching was estimated to 22-154 million USD, which would imply 254-1780- USD per visitor (depending on if the median or the mean is used).

Summary and Discussion

The result of the study provides two interesting questions worth pondering on. Why does revealed and stated preferences result in such totally different values, are there theoretical and/or empirical explanations to this? And, second, given the result of the stated preference question, why are there no statistically significant differences in the welfare estimates between the two periods, since the respondents attach high estimates to access to reefs in general and a major deterioration in the quality of the reefs has *de facto* occurred.

Let's start with the last issue by assessing the result of the questions posed to the respondents in the second survey regarding knowledge and attitude towards coral bleaching. The consumption of international recreational goods differs compared many other recreational activities in that they in general are only visited once and that the visitors have no previous experience of the site. The decision to visit a certain site then depends on information from other sources. This means that effort is spent on information searching, which will vary between individuals. Regarding the bleaching event in 1998 the media coverage was substantial, especially in dive journals (Westmacott

[32] This was for example the case for the UK, where the individual price ranged between 500 and 5000 USD.

[33] Zanzibar, which formed a union with Tanganyika in 1964, is an enclave to what is now Tanzania having its own Government. Having their own custom authorities all individuals entering the island are registered, which is the source of the statistics. In Mafia, which was part of Tanganyika, does not have this sort of registration and anybody who has entered Tanzania will enter unregistered to Mafia.

[34] The consumer surplus is estimated from; $CS = \alpha(\tilde{p} - p') + \beta/2\,(\tilde{p}^2 - p'^2)$, where $\tilde{p}_z = -\alpha/\beta$.

et al 2000). The question is, did the visitors in the sample know about it? The results are displayed in Table 8.

Variable	Mean (yes =1, no=0)	Std.Dev.	Cases
Zanzibar			
Heard of bleaching?	.286486486	.453346351	185
Influence choice of destination?	.725490196	.450707505	51
Would dive on bleached reef?	.400000000	.507092553	15
Seen bleached coral in Zanzibar?	.263157895	.446258350	38
Mafia			
Heard of bleaching	.625000000	.494535355	24
Influence choice of destination?	.866666667	.351865775	15
Would dive on bleached reef?	.333333333	.577350269	3
Seen bleached coral in Zanzibar?	.166666667	.380693494	24

Table 8. Result of responses to questions about information and behaviour related to coral bleaching.

Significantly more individuals had "heard of "coral bleaching in the Mafia sample. This is in line with earlier results that more "serious" divers visit Mafia. This question was followed by a request to state what they knew about bleaching. In the Mafia sample the majority related bleaching to raising temperature, global warming and *El niño* while in the Zanzibar sample they commonly stated the *result* of bleaching; that the corals are white or that the corals are dead. This seems to indicate that more devoted divers are also more knowledgeable. It also highlights the large spectrum of different sorts of consumers that exists for this activity ranging from "accidental" divers to divers who are highly dedicated to the sport and carefully selects sites to visit. It also means that there is a market for low quality reefs, maybe even dead reefs, but only to a certain segment of divers. The fact that new divers are being certified at an increasing rate every year means that this market is only increasing. Another option is to profile the business to other types of coastal tourism, which is what the Maldives did after the bleaching and as mentioned they have increased their visitation rate.

Next, the visitors were asked if coral bleaching would influence their choice of destination. Mafia visitors would to a larger extent avoid visiting a site affected by bleaching but the majority of the Zanzibar visitors would as well. This question was followed by a "why", with the common response that it was not worth diving on damaged reefs, which contradicts the above that there is a market for damaged reefs. The respondents who stated that bleached reefs would not affect their decision to visit a site were asked if they would dive at such a site. About one third would dive even if the reefs were bleached. Lastly they were asked if they had seen bleached reefs while diving during their stay in Zanzibar/Mafia. Surprisingly, a larger portion had seen bleached reefs on Zanzibar than on Mafia, despite the fact that biological surveys showed the opposite. One reason for this might be that the number of tourists on Zanzibar is considerably larger and the dive operators do not have other options than to bring them to damaged reefs. Mafia can still provide excellent diving, for example, a few "walls" that since they extend to deeper water were less exposed to the raise in temperature causing the bleaching. This is, however, coupled to the preceding argument that there are fewer visitors on Mafia meaning that these walls suffice to satisfy the expectations of the visitors and are not congested.

Regarding the difference between revealed and stated methods, the main theoretical explanation lies in the reference level. In the revealed preference situation the individual is not fully informed and the preferences are revealed solely based on *expectations* of the site and its reefs. It means that the reference level is subjective and imagined and varies between individuals. For the stated preference the individual's

reference level is *at the site* meaning that all individuals in the sample have approximately the same reference level. Does the reference level matter empirically (or methodologically)? If an individual, for example, is ill informed (or falsely informed) and expectations are not met will he "over-react" in a stated preference question?

One empirical explanation might be that other variables did not remain unchanged. It was for example observed that the factual cost of travelling from different countries had changed between the two periods, which impacts both the revealed and stated preference estimate. Another thing is that the revealed preference data deals with populations of the world resulting in that even marginal changes in the estimate of a variable, estimated that are sometimes approximations, cause large changes in the result. The advantage with the data was, however, that exact information of the number of visitors from the respective countries was available.

Conclusion and thoughts of further studies

The result of the study pointed in different directions; according to the stated preference questions there had been no loss in welfare caused by the coral bleaching, unless the bleaching dummy is interpreted. The revealed preference result shows high welfare losses but visitors keep coming to the sites and on the question if the individuals had seen any bleaching while diving the answer was mostly no. So, what does this mean? Should the Government of Zanzibar not worry about natural phenomena affecting their underwater environment? Is there any danger in profiling the business in a specialised form such as towards dive tourism? The Mafia case showed that it is possible to have some sort of resilience in the ability to cope with chocks such as coral bleaching if the number of tourists is limited to the extent that any change (within certain boarders) in the supply of healthy reefs can be compensated for. In the case of Mafia some of the most well known reefs, praised in the most common guidebooks, were completely ruined[35]. The number of exclusive dive sites was, however, large enough to provide the product expected by even experienced divers. Less controllable does the effect from political instabilities seem to be. As was observed in Graph 1 the tourists seem to be more sensitive to political instabilities and epidemic outbreaks than to a natural catastrophe such as the bleaching.

An area that needs further studies is the role of information. It is in the interest of the tourist industry to not spread information with potential negative effect on the industry while it is often in the interest of the research community to do so. The very patchy nature of the damages from bleaching renders it difficult to provide an accurate description of the change in quality at any tourist destination. To intense negative reporting could destroy an industry that is very important for the local economy by "marking" a site. There are recovery opportunities for the reefs, in Mafia the local community has participated in replanting the corals. If the scientific reporting had used Mafia as an example of the "worse case" in a way that reached information searching divers leading to a collapse of the market. This is because Mafia was able to provide the product requested by even serious divers and since the number of visitors is few they do not cause any distress to the eco system and its recovery. Correct in long term perspective and balanced information is accordingly very important. The media coverage of the event varied between countries (Westmacott, 2000), which is something that could be assessed. The event was also very well covered in dive magazines, which might be one explanation to why experienced divers are more aware than an occasional diver.

[35] Lonely Planet (1997), for example praises "Tutia reef" which was one of the worse affected areas in the whole region (Obura, 2002).

Appendix

Appendix ***A.***

Zanzibar w_{access}

Probit (WTP>0)=1

Variable	Coefficient	Standard Error	t-ratio	P-value]
Constant	.3977972952	.84036518E-01	4.734	.0000
INCOME	-.1031635458E-02	.11886338E-01	-.087	.9308
SEX	.2306504855E-01	.40659680E-01	.567	.5705
EDUCAT	.5125642974E-02	.23290128E-01	.220	.8258
PROPZNZ	-.2123168251	.62460309E-01	-3.399	.0007
ZDAYCOST	-.4090096687E-03	.20988949E-03	-1.949	.0513
BLEKNING	-.9604881514E-01	.59003221E-01	-1.628	.1036

Truncated on WTP>0

Variable	Coefficient	Standard Error	t-ratio	P-value
Constant	-36.94007746	150.34965	-.246	.8059
INCOME	51.72573771	20.290298	2.549	.0108
SEX	45.81754095	68.499492	.669	.5036
EDUCAT	-47.37006264	40.178851	-1.179	.2384
PROPZNZ	122.2318793	106.07266	1.152	.2492
ZDAYCOST	1.293400324	.43974834	2.941	.0033
BLEKNING	-307.7018931	99.704367	-3.086	.0020

Zanzibar $w_{quality}^{no\ reefs}$

Probit (WTA>0)=1

Variable	Coefficient	Standard Error	t-ratio	P-value
Constant	.2693337958	.13595718	1.981	.0476
INCOME	-.4466504839E-02	.13632745E-01	-.328	.7432
SEX	-.6480899380E-01	.51909597E-01	-1.248	.2118
EDUCAT	-.1607950145E-01	.28531689E-01	-.564	.5730
COSTDIV	.2008392885E-03	.16132501E-03	1.245	.2132
IMPCORAL	.1381557332	.99381340E-01	1.390	.1645
PROPZNZ	.1567252548E-01	.69780223E-01	.225	.8223
QUALITY	-.4983641554E-02	.58505149E-02	-.852	.3943
BLEKNING	.1423733644	.50432222E-01	2.823	.0048

Truncated on WTA>0

Variable	Coefficient	Standard Error	t-ratio	P-value
Constant	-609.0925146	232.45227	-2.620	.0088
INCOME	38.17849288	13.473748	2.834	.0046
SEX	1.009348100	48.663876	.021	.9835
EDUCAT	-55.32437934	29.289547	-1.889	.0589
COSTDIV	.1422332352	.81111561E-01	1.754	.0795
IMPCORAL	164.9416531	73.216620	2.253	.0243
PROPZNZ	410.5954259	127.90420	3.210	.0013
QUALITY	4.244350395	5.5843728	.760	.4472
BLEKNING	59.18662969	76.534256	.773	.4393

Zanzibar $w_{quality}^{no\ reefs\ weak\ compl.}$

Probit (WTA>0)=1

Variable	Coefficient	Standard Error	t-ratio	P-value
Constant	.2510466015	.17329928	1.449	.1474
INCOME	-.2160593824E-01	.17358815E-01	-1.245	.2133
SEX	-.3498135900E-01	.63259055E-01	-.553	.5803
EDUCAT	.1805133126E-02	.36117726E-01	.050	.9601
COSTDIV	.2093190993E-03	.19894484E-03	1.052	.2927
IMPCORAL	.1503500002	.11691978	1.286	.1985
PROPZNZ	-.1282002460	.89011187E-01	-1.440	.1498
QUALITY	-.2615376335E-02	.74733087E-02	-.350	.7264
BLEKNING	.5354018913E-01	.74228541E-01	.721	.4707

Truncated on WTA>0

Variable	Coefficient	Standard Error	t-ratio	P-value
Constant	-292.3401844	154.13155	-1.897	.0579
INCOME	26.68443487	11.337973	2.354	.0186
SEX	12.00156299	43.841211	.274	.7843

EDUCAT	-33.06087438	24.647605	-1.341	.1798
COSTDIV	.9434807527E-01	.11036091	.855	.3926
IMPCORAL	.9022798262E-01	72.742870	.001	.9990
PROPZNZ	332.4018902	93.900266	3.540	.0004
QUALITY	-3.661632474	5.2148757	-.702	.4826
BLEKNING	87.18399952	64.610446	1.349	.1772

Mafia w_{access}

Probit (WTP>0)=1

Variable	Coefficient	Standard Error	t-ratio	P-value
Constant	-.8850838298	.35386824	-2.501	.0124
INCOME	.7157038647E-01	.37863126E-01	1.890	.0587
SEX	.3022424244	.12024818	2.513	.0120
EDUCAT	.1093962266	.70664900E-01	1.548	.1216
PORTMAFI	.2422403622	.17917423	1.352	.1764
MDAYCOST	.7704462362E-03	.48402869E-03	1.592	.1114
BLEKNING	.3937291107E-01	.13211779	.298	.7657

Truncated on WTP>0

Variable	Coefficient	Standard Error	t-ratio	P-value
Constant	-311.8522921	277.81368	-1.123	.2616
INCOME	18.57192929	19.363548	.959	.3375
SEX	-126.3668392	105.27006	-1.200	.2300
EDUCAT	48.58629390	49.738853	.977	.3287
PORTMAFI	-242.6694258	123.66796	-1.962	.0497
MDAYCOST	1.015844163	.13097902	7.756	.0000
BLEKNING	-110.6309669	84.044479	-1.316	.1881

Mafia $w_{quality}^{no\ reefs}$

Truncated on WTA>0

Variable	Coefficient	Standard Error	t-ratio	P-value
Constant	-664.0380312	629.54452	-1.055	.2915
INCOME	36.80112903	49.132995	.749	.4539
SEX	126.1527780	191.69245	.658	.5105
EDUCAT	170.5771697	99.020244	1.723	.0850
COSTDIV	1.609783913	.32816552	4.905	.0000
IMPCORAL	-108.4236567	270.77415	-.400	.6888
PORTMAFI	-89.93106187	263.46787	-.341	.7329
QUALITY	11.46085164	21.966755	.522	.6019
BLEKNING	-555.1484240	218.15886	-2.545	.0109

Mafia $w_{quality}^{no\ reefs\ weak\ compl.}$

Probit (WTA>0)=1

Variable	Coefficient	Standard Error	t-ratio	P-value
Constant	-1.099488700	.65180527	-1.687	.0916
INCOME	.1215663138	.53882914E-01	2.256	.0241
SEX	.3996253370	.13232631	3.020	.0025
EDUCAT	.8637168895E-01	.91159031E-01	.947	.3434
COSTDIV	-.3007744151E-04	.30856436E-03	-.097	.9223
IMPCORAL	.1823722406	.22494201	.811	.4175
PORTMAFI	.3567183742	.24083896	1.481	.1386
QUALITY	-.5666077682E-03	.22496538E-01	-.025	.9799
BLEKNING	.7785175496E-01	.19063560	.408	.6830

Truncated on WTA>0

Variable	Coefficient	Standard Error	t-ratio	P-value
Constant	450.5913535	485.21002	.929	.3531
INCOME	8.687829762	25.269113	.344	.7310
SEX	-233.1731814	100.75979	-2.314	.0207
EDUCAT	-26.59188622	57.537272	-.462	.6440
COSTDIV	.7205224913	.14652343	4.917	.0000
IMPCORAL	-288.7750702	206.24834	-1.400	.1615
PORTMAFI	-482.8199199	128.39355	-3.760	.0002
QUALITY	9.203204488	11.123208	.827	.4080
BLEKNING	-255.5576070	91.436866	-2.795	.0052

Appendix ***B.***

Variable	Coefficient	Standard Error	t-ratio	P[|T|>t]	Mean of X
1996/97					
Constant	1217.155350	314.51097	3.870	.0038	
AVERAGE p_z	-.6771865463	.26638766	-2.542	.0316	998.72727

Fit:R-squared=.417940, Adjusted R-squared =.35327Model test: F[1,9] =6.46, Prob value =.03160

CHOKEPRICE[1]=1797

Aggr. CS[2]= .10553888804773450D+09

Constant	1252.197829	297.23536	4.213	.0023	
MEDIAN p_z	-.8238617248	.29031689	-2.838	.0195	863.45455

Fit:R-squared=.472237, Adjusted R-squared =.41360 Model test: F[1,9]=8.05, Prob value =.01947

CHOKEPRICE=1520

Aggr. CS= .72602462853248000D+08

1999					
Constant	1000.678289	272.12162	3.677	.0051	
AVERAGE p_z	-.7442306357	.31086052	-2.394	.0403	740.45455

Fit: R-squared= .389073, Adjusted R-squared = .32119 Model test: F[1, 9] =5.73, Prob value =.04029

CHOKEPRICE =1345

Aggr. CS= .49451707604373660D+08

Constant	1005.606233	259.62452	3.873	.0038	
MEDIAN p_z	-.7531977722	.29495862	-2.554	.0310	738.18182

Fit:R-squared= .419320, Adjusted R-squared =.35480, Model test: F[1,9] = 6.50, Prob value =.03123

CHOKEPRICE=1334

Aggr. CS= .43113959753426490D+08

1 the chokeprice is estimated from $\tilde{p}_z = -\alpha/\beta$

2 The consumer surplus is estimated from; $CS = \alpha(\tilde{p} - p') + \beta/2\,(\tilde{p}^2 - p'^2)$

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