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Non-market values of algae beach-cast management – Study site Trelleborg, Sweden

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ABSTRACT

Eutrophication is one of the most serious global threats to coastal areas. One effect of eutrophication is seasonal macroalgal blooms. As a consequence, large amounts of beach-cast algae are today reported from coastal areas worldwide. In this study, we analyze nonmarket benefits by capturing local residents' Willingness To Pay (WTP) for an environmental program to regularly remove and utilize beach-cast algae to produce bioenergy and biofertilizer. Results indicate a considerable WTP among local residents in the Baltic Sea study site. This WTP estimate together with a potential increase in non-resident beach tourism amounts to potentially substantial welfare benefits from the environmental program. These benefits could encourage similar environmental programs in the future.

1. Introduction

Eutrophication is one of the most serious global threats to coastal areas (Diaz and Rosenberg, 2008). One visible and very harmful effect of eutrophication in combination with climate change is seasonal mass occurrences of micro- and macroalgae and cyanobacteria. Seasonal blooms have been reported from coastal communities worldwide (Pettersson, 2001; Filipkowska et al., 2008; Newton and Thornber, 2012; Liu et al., 2013; Pechsiri et al., 2014).

This study focuses on seasonal macroalgae blooms in particular, since these result in large amounts of decaying biomass. The blooms reduce water clarity and produce anoxic conditions that can result in the decline of key species (Kautsky et al., 1986; Elmgren, 1989), negatively impacting biodiversity and fish reproduction (e.g. Isaeus et al., 2004; Malm et al., 2004 and references herein). Further, when substantial amounts of algae are washed ashore and decompose, the recreational value of a coastal area can be reduced. This reduced recreational value is a strong driving force for coastal communities worldwide to establish strategies and environmental programs to cope with large amounts of marine biomass.

One common strategy is to collect the algae in large piles and dump it back into the sea at the end of summer. However, this is costly and does not eliminate all welfare losses (Filipkowska et al., 2009; Roca et al., 2009; Mossbauer et al., 2012). For example, the odor from the decomposing algae is not necessarily reduced. In addition, the strategy is not environmentally beneficial, since large piles of decomposing algae may result in substantial methane leakage. Further, fossil fuels are used during collection and dumping of the algae.

In the current study we address how local residents of a Baltic Sea resort value reduced quantities of beach-cast algae on beaches and along the coastline. The reduction would be achieved by implementing an environmental program to collect the algae and use the biomass for production of biogas and biofertilizer. The program would thus not only avoid welfare losses by removing the algae biomass from recreational areas: it would also add environmental benefits, including production of renewable energy from a local resource (thus reducing GHG emissions) and recirculating nutrients from the eutrophied coastal zone onto farmland.

One issue, however, of this and other environmental programs

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Fig. 1. Map of the Baltic Sea area, with the municipality of Trelleborg marked by a big red star. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

in coastal areas, is that the market value is too low to motivate implementation. Local coastal authorities are therefore often reluctant to invest in and explore the possibilities of such environmental programs.

It is therefore essential that the nonmarket values (avoided welfare losses) of such programs are mapped out. It is a matter of priority to integrate this monetization in decision and strategy formation for local authorities, by setting the avoided welfare losses against the costs of implementing the environmental program. In addition, in a larger context, the quantification of welfare losses associated with algal beach-cast should be added to other welfare losses resulting from eutrophication. These should then be set in relation to costs for implementing eutrophication reduction programs, such as the European Union Water Framework Directive and implementation of the Baltic Sea Action Plan.

Numerous studies have looked at environmental programs to utilize marine biomass in the Baltic Sea area (Lindahl et al., 2005; Filipkowska et al., 2008; Gröndahl, 2009; Blidberg and Gröndahl, 2012a; Risén et al., 2013). However, the non-market benefits of these programs have been poorly studied and quantified in the literature.[1] Therefore, in order to capture the avoided welfare losses, our study estimates local residents' Willingness To Pay (WTP) for such an environmental program in the Baltic Sea study site.

2. Background and methods

2.1. Case study area

Seasonal blooms of cyanobacteria and macroalgae are a serious concern for numerous coastal communities worldwide (Newton and Thornber, 2012; Liu et al., 2013; Pechsiri et al., 2014). The Baltic Sea is no exception; indeed, it is considered one of the most polluted seas in the world and suffers heavily from the negative effects of eutrophication.

The small municipality of Trelleborg in southern Sweden (Fig. 1), with 42 000 inhabitants, was chosen as a study area because of the great problems it experiences with the accumulation of opportunistic red filamentous macroalgae such as *Polysiphonia fucoides* and *Ceramium tenuicorne* on beaches and shorelines in the summer. The municipality has long sandy beaches with shallow waters and lies in a transition zone between the brackish Baltic Sea and the saline Kattegat. As the beaches and coastline can be accessed freely, we are unable to use a market price to value the services from these resources. Today there is hardly any national parks, recreational areas or beaches with entry-fees in Sweden (due to the law Allemannsrätten). This also suggests that respondents may have limited experience in valuing beach-cleaning services in general in Sweden.

2.2. Environmental program

In this study we focus on local residents' WTP for one potential environmental program. The aim of the program is to produce biogas and biofertiliser from the retrieved macroalgae through Anaerobic Digestion (AD) (e.g. Hughes et al., 2012; Risén et al., 2014). Anaerobic digestion is a common waste handling strategy where biological material is broken down by microorganisms in multiple steps in an oxygen free environment. The end products are mainly carbon dioxide and methane together with a residual in the form of biological material.

The local authority has recently constructed a customized dry batch biogas facility to process the algae and plans to use the digestate as fertilizer. The motivation for the program is to clean the beach: there is no net profit from the biogas and biofertiliser recovery at present. It is rather viewed as an appropriate waste handling strategy. As mentioned, the program may not only contribute increased recreational values to the area but also lead to nutrient recirculation from the eutrophied coastal zone onto local farmland. The program produces renewable energy and can also provide a number of secondary benefits, such as greenhouse gas

[1] See for example Söderqvist and Scharin (2000), Lindahl et al. (2005), Kosenius (2010), Wang and Calderon (2012), Ahtiainen and Vanhatalo (2012), the Swedish Agency for Marine and Water Management (2013), and Stybel and Schernewski (2013) for studies on associated topics. These studies examine the welfare effects of improved water quality through measures such as mussel farming.

Table 1
Payment card used in the survey.

☐ 0 SEK/year (0 €/year)	☐ 800 SEK/year (88 €/year)	☐ Don't know
☐ 50 SEK/year (5.5 €/year)	☐ 1000 SEK/year (110 €/year)	
☐ 100 SEK/year (11 €/year)	☐ 1200 SEK/year (132 €/year)	
☐ 200 SEK/year (22 €/year)	☐ 1800 SEK/year (198 €/year)	
☐ 400 SEK/year (44 €/year)	☐ 2200 SEK/year (242 €/year)	
☐ 600 SEK/year (66 €/year)	☐ >2200 SEK/year (>242 €/year)	

(GHG) mitigation, reduced local odor from decomposing algae, and reduced local anoxic conditions (Blidberg and Gröndahl, 2012b). A more detailed description of the environmental program is given in Risén et al. (2014).

2.3. Survey methodology

Several methods are available to determine non-market benefits. In this study, we used contingent valuation (CV), a survey-based economic technique for the valuation of non-market goods (see for example Bateman et al., 2002). The method is commonly utilized to capture WTP for coastal environmental programs, see for example Garcia-Llorente et al. (2011). The Choice Experiment method was not used, as early focus group sessions showed that it was difficult to find an efficient model design due to the linear relationships between attributes.[2]

Here a split sample was used, where respondents received either a payment card or an interval open-ended (IOE) question. The payment card format was chosen as it is more informative and cheaper to implement than a dichotomous choice format (Bateman et al., 2002). Open-ended formats in general are not recommended by NOAA; however, recent studies highlight that an interval open-ended format may have some advantages. One appealing property of this format is that the uncertainty of the stated WTP can be determined based on the width of the WTP interval – see for example Håkansson (2008) and Voltaire et al. (2013) for discussion of this topic.

In the survey the respondents were asked the question "How much are you willing to pay as a maximum for Program A per year?" Respondents that got the payment card marked their answer in the card. The payment card was first designed as suggested by Rowe et al. (1996), with 28 options. However, focus group sessions revealed that respondents found it difficult to choose between very similar numbers, so the resolution in the final design was greatly lowered. Table 1 show the levels that were used in the payment card.

Respondents that got the interval open-ended format answered the question "I am willing to pay between ____ and ____ SEK per year".

In the current study, the information from the IOE format will be viewed as a complement to the information collected via the payment card format. Although the IOE format contains information about the respondents' WTP, the chief reason for including the IOE question was to obtain a monetary measure of the uncertainty associated with the WTP for the different environmental programs. This is also the main reason why more respondents received the payment card version of the questionnaire. However, Voltaire et al. (2013) suggest that the information from the IOE format can be used to calculate an uncertainty adjusted max WTP. Voltaire et al.'s uncertainty adjusted WTP is given by the expression Adj WTP $= WTP_{u.b.} - [(WTP_{u.b.} - WTP_{l.b.}) \times (WTP_{u.b.} - WTP_{l.b.})/WTP_{u.b.}]$,
where $u.b.$ = upper bound and $l.b.$ = lower bound, and will be used in the comparison of the results from the payment card and IOE format.

For the postal samplings, 550 randomly chosen respondents received the payment card format and 200 respondents the IOE format. These respondents were randomly selected based on their home address. The survey company Enkätfabriken carried out the sampling, with the aim to produce a representative sample. As a complement to the postal questionnaires, an additional subsample of questionnaires with the IOE format was gathered by face-to-face interviews with 52 randomly selected residents in the study area. The survey staff that performed the face-to-face interviews was instructed to ask every 10 person walking past them at a public place. Column 1–3 in Table 3 summarizes the sampling methods, type of WTP questions and sample size.

All respondents were permanent residents of Trelleborg, and the demographic distribution of age, gender, income and educational level resembled that of the municipality. The questionnaire design followed Bateman et al. (2002). Respondents were reminded of their budget constraints in connection with the WTP questions. An increase in municipal tax was chosen as the payment vehicle, since beach-cast collection is currently integrated into the municipal beach-cleaning service and funded through the budget set by municipal tax income. The questionnaire was administered in Swedish; a complete translation is given in Appendix 2 (Electronic Supplementary Material).

2.3.1. WTP

In connection with the WTP question, respondents received background information about algae accumulation on beaches, a table with information (Table 2) on current algae removal conducted by the municipality, and information about two potential new programs, A and B, both of which involved extended algae collection and utilization of the biomass for biogas and biofertilizer production.

Respondents were also shown pictures of beaches in the municipality before and after algae removal (Fig. 2). In addition, respondents were shown images describing the present water quality and the expected water quality for programs A and B (see Appendix 2). A map showed the beaches where algae collection is conducted at present and in the respective programs.

In order to avoid and identify sequencing effects the two WTP questions were randomized so that about 50% of the respondents first stated their individual WTP to the smaller program A and vice versa. We used advanced disclosure (respondents were given information about both programs before the WTP questions), suggested by Bateman et al. (2002) in order to avoid answers that are not scale sensitive (scope bias).

The WTP question was followed by additional questions, for instance to identify protest answers and measure respondents' uncertainty about their stated WTP on a five-point graded scale. The scale ranged from one, *very uncertain*, to five, *very certain* (see e.g. Logar and Bergh, 2012).

In total 349 questionnaires were returned, giving an overall

[2] Namely, increasing the collection of algae tenfold, from e.g. 500 t to 5000 t, would also increase the energy production and nutrient mitigation tenfold, as well as reducing the GHG emissions tenfold. For details see Table 2.

Table 2
Information given in connection with the WTP question.

Benefit	Present	Program A	Program B
Nutrient mitigation[a]	1 t nitrogen	14 t nitrogen	108 t nitrogen
Energy production per year in number of heated houses[b]	10 houses	100 houses	800 houses
Reduction of GHG emissions[c]	Annual emissions from 6 people	Annual emissions from 63 people	Annual emissions from 504 people
Local water quality	Same	Small improvement	Great improvement
Local odor	Same	Small improvement	Great improvement
Amount of retrieved algae (t)	500 t	5000 t	40 000 t

[a] The annual nutrient losses to the Baltic Sea from farmland in Trelleborg is about 1000 t of nitrogen.
[b] Mean annual energy demand 20000 kWh.
[c] Mean annual emissions of 10 t of CO_2 per person from consumption.

Fig. 2. A beach in Trelleborg before (left) and after (right) algae collection.

Table 3
Total sample size, number of respondents, response rate, number of WTP observations, non-completion rate, and zero responses from the two elicitation formats (payment card (PC) and interval open-ended (IOE) for Program B).[a]

Sampling method	Type of WTP question	Sample size	Number of respondents	Response rate (%)	Number of WTP observations	Non- completion rate (%)	Zero responses (%)
Postal	PC	550	224	41	141	37	22
Postal	IOE	200	73	37	46	37	45
Face-to-face	IOE	52	52	[b]	35	33	24[c]
Total		**802**	**349**	**40**	**227**	**37**	**28**

[a] In the analysis, respondents with many missing observations, strategic or protest answers, and respondents with high uncertainty were removed from the total sample shown here, as detailed in Section 2.3.
[b] Response rate calculated for postal subsamples only.
[c] This subsample did not show any elevated zero response level in relation to the payment card. This was perhaps due to the face-to-face interview technique and the oral explanation of the concept given to respondents in preparation for the WTP question prior to receiving the questionnaire.

response rate of 40% (detailed in Table 3). All subsamples displayed similarly satisfactory response rates, with in total 227 observations on WTP obtained. Respondents who did not respond to the socio-economic questions were removed, as were those who gave answers protesting against the payment vehicle.[3] Both formats resulted in a high level of zero responses that were identified as protest votes[4] against the payment vehicle (in total 28% zero respondents for Program B).

The proportion of zero responses was higher for the IOE format with the postal subsample (Table 3). This agrees with previous findings on other types of open-ended formats (Donaldson et al., 1997; Smith, 2000). One of several possible explanations for the higher frequency of zero responses with the IOE subsample is that the format was less familiar to respondents, since they are more accustomed to reacting to prices than setting them (Shaikh et al., 2007).

2.4. Econometric model

To analyse whether there were differences in WTP between different categories of respondents, we estimated ordered probit models. The ordered probability model is built around the latent regression

$$\gamma_i^* = \acute{\beta} x_i + \varepsilon_i, i = 1 \ldots n, \tag{1}$$

where γ_i^* is the underlying maximum WTP for individual i, the vector x_i is a set of explanatory variables, β is a vector of parameters, and ε_i is a residual with $\mathrm{E}[\varepsilon_i] = 0$ and $\mathrm{Var}[\varepsilon_i] = 1$. The estimations were carried out with Limdep 4.0, see for example Greene and Hensher (2010) for a detailed description of ordered probit models.

By using ordered probit models, we can include the stated WTP from both the payment card and OEI format in the same regression.

[3] After visual inspections of boxplots, one further outlier was identified as a strategic answer and removed from the IOE format (WTP EUR 17 600).

[4] Protest votes against the payment vehicle were identified by a follow-up question after the WTP question, asking about the respondent's rationale for their WTP statement (Appendix 2).

Table 4
Summary statistics of the sample.

Variable		Mean
Year of birth		1959.6
Gender	Female	0.48
	Male	0.52
Education	Elementary school	0.13
	High school <3 y.	0.12
	High school ≥3 y.	0.18
	Higher edu. < 3 y.	0.20
	Higher edu. ≥ 3 y.	0.35
	Education missing	0.02
Income	Lowest	0.21
	Next lowest	0.22
	Middle	0.22
	Next highest	0.18
	Highest	0.10
	Income missing	0.07

Note: Min age 18 year, max age 84 year. Income interval: Lowest € 0–1320 per month, Next lowest € 1321–2200 per month, Middle € 2201–3080 per month, Next highest € 3081–3960 per month, Highest more than € 3960 per month.

In the models the dependent variable takes a value of zero to six depending on the stated WTP.[5]

The individual characteristics that we included as explanatory variables were: age, gender, income and education. Summary statistics for these variable are shown in Table 4. In addition, we include a variable that captures how the respondent's perceived the smell (mean 4.05, std 0.97) from decomposing algae,[6] based on information from the questionnaire.

2.4.1. Marginal effects

As there is no natural mean function for the ordered probit model, the interpretation of the parameters in this model is more complex than in an ordinary regression model, see e.g. Daykin and Moffatt (2002). The marginal effects of a change in an explanatory variable are therefore analyzed via the change in the cell probabilities (the intervals in the payment card). For continuous variables, the effects of changes in the explanatory variables on the cell probabilities are calculated as:

$$\delta_j(\mathbf{x}_i) = \frac{\partial \text{Prob}[y = j|\mathbf{x}_i]}{\partial \mathbf{x}_i} = \left[f\left(\mu_{j-1} - \beta'\mathbf{x}_i\right) - f\left(\mu_j - \beta'\mathbf{x}_i\right)\right]\beta$$

where f(.) represents the standard normal density function. For a dummy variable, we follow Greene and Hensher (2010) and calculate the marginal effect as the difference in probabilities. If we assume that D represents a dummy variable and that λ is the coefficient on D, then the change in probability is calculated by:

$$\Delta Prob_j(D) = \left[F\left(\mu_j - \beta'\mathbf{x}_i - \lambda\right) - F\left(\mu_{j-1} - \beta'\mathbf{x}_i - \lambda\right)\right] - \left[F\left(\mu_j - \beta'\mathbf{x}_i\right) - F\left(\mu_{j-1} - \beta'\mathbf{x}_i\right)\right],$$

where F(.) is the cumulative distribution function.

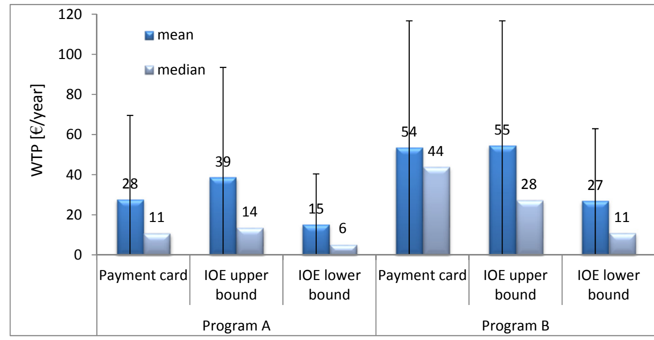

Fig. 3. Mean and median willingness-to-pay (WTP) for Programs A and B[10] according to the payment card and IOE upper and lower bound, with the standard deviation shown by bars. For the payment card calculations we used the value that the respondents marked in the payment card. For both formats, preference uncertainty was accounted for by removing respondents who state that they are *very* uncertain about their WTP from the sample.

For inference purposes, we use a sandwich estimator to account for heteroscedasticity.[7] The estimations were carried out using Nlogit 4.0.

3. Results

Respondents reported a high visiting frequency, with 57% stating that they visited the beach several or a number of times a week during the summer. Most respondents used the beach for swimming, walking, picnicking or sunbathing. The results from the survey suggest a significant increase in the stated visiting frequency when respondents were given the option of an algae-free beach,[8] which indicates that increased retrieval is of value for residents.

As indicated by the increased visiting frequency, respondents displayed a considerable mean WTP, equating to EUR 54 per person annually for the larger Program B and EUR 28 per person annually for Program A, when the payment cards format was used (Fig. 3). In the calculations of the mean value we have used the value that the respondents marked in the payment card, see Table. A one tailed Man Whitney *U* test found a significant difference between WTP for program A and B for the open ended format, and a significant difference in WTP between programs A and B for the payment card format. This indicates that the results display scale sensitivity.

For Program A the mean WTP from the payment cards format lay in the middle of the WTP interval for the IOE format. This result is also supported by findings in Banerjee and Shogren (2014).[9] In addition, a one tailed Man Whitney *U* test found no significant difference between WTP for program A between the payment card and IOE format. It thus seems reasonable to use the benefit values

[5] Since relatively few respondents stated a WTP above SEK 800 (€88) we have added respondents with a stated WTP above SEK 800 (€88), to the highest interval, six.

[6] To capture the respondents preferences concerning the smell of decomposing algae, the following questions was asked: How well do you agree with the following statements? The smell of decomposing algae is a large problem during summer: 1 = Completely agree, 5 = Do not agree at all. A five point Likert scale was used.

[7] The patterns of the statistical significance for the marginal effects will usually echo thus for the estimated coefficients in Equation (1), (Greene and Hensher, 2010). These authors also have preference, on the methodological basis, for inference on the estimated coefficients and not on the marginal effects. We share this view, and base our inference on the estimated coefficients in Equation (1).

[8] Seventy-five percent stated that they would visit the beach one or several times per week if it was kept free of algae biomass. A paired *t*-test indicates a significant increase in visiting frequency at a 5% significance level when respondents are posed with an algae-free beach ($p = 0.00$, $n = 300$).

[9] In a second-price action Banerjee and Shogren (2014) asked bidders with a point value to state their WTP as an interval. These bidders chose to form the interval with the point estimate as the mean of the interval. Correspondingly, when bidders with an interval value were asked to state a point estimate, they let the mean of the interval represent their preference.

[10] A group of respondents (17% and 29%, respectively, for the payment card and IOE postal samples) stated a zero WTP for increased algae retrieval (after removal of protest responses against the payment vehicle).

from the payment card format.

For Program B, the mean WTP from the payment card format is close to the upper bound WTP from the IOE format.[11] However, the answers from the postal sample IOE format appear to suffer from excess zero responses. For respondents with a WTP larger than zero, the mean WTP for the payment card format is EUR 69 per person, whereas the upper and lower mean WTPs for the IOE format are EUR 85 and EUR 42, with a mean of EUR 64. Thus if we assume that the two samples have the same proportion of subjects with a true WTP of zero, the mean WTP from the payment cards is close to the mean of the interval from the IOE format.[12]

The uncertainty adjusted max WTP, suggested by Voltaire et al. (2013), also suggest that the mean of the WTP interval should be used to represent the maximum WTP for Program B. For Program B the uncertainty expression $(WTP_{u.b.} - WTP_{l.b.})/WTP_{u.b.}$ in Voltaire et al.'s equation is (55-27)/55 = 0.51, implying that the uncertainty adjusted WTP lies in the middle of the WTP interval.[13]

In the literature, the width of the range (WTP upper bound − WTP lower bound) has also been viewed as a measure of the uncertainty associated with the stated WTP (e.g. Håkansson, 2008; Hanley et al., 2009). Using this definition, we see that the uncertainty is at approximately the same level for both programs: EUR 24 and EUR 28 for Program A and Program B, respectively. At the same time, the mean upper bound WTP increases by 41 percent.

The estimation results from the ordered probit model is presented in Table 5. The results suggest that age and gender had no significant effect on an individual's WTP. However, individuals with higher income are willing to pay more than those with lower income. In general, individuals with a longer education are also willing to pay more than those with a shorter education. The exception being individuals with a long university education (three years or more). The sign of the point estimate must, however, be interpreted with caution, since it does not tell us how all cell probabilities will be affected by a change in the covariate. It is only for the first and last cells that we can be sure about the sign of the change in the cell probability.

For program B, Table 6 reveals that the sign change in cell probabilities occur between cells 3 and 4 (at a WTP of €44) for the covariates in the model. Thus, a negative point estimate increases the probability of having a maximum WTP in the four lowest cells, while a positive one decreases the probability. The largest difference in cell probabilities is for the group of individuals in the highest income group compared to the group of individuals in lowest income group. For individuals in the highest income group, the probability of having a maximum WTP in the highest cell, i.e. €88 or more, is 30 percentage points higher than for individuals in the lowest income group. For the educational variable, the largest marginal effects are found for groups of individuals with a longer high school education (three years or more) and individuals with a shorter university (higher) education (less than three year). The probability for stating a max WTP in the highest cell (€88 or more) for these individuals is about 23 percent higher than for individuals with the lowest education (elementary school).

For program A the sign change in cell probabilities occur between cells 1 and 2 (at a price of (€11)) for the covariates in the model, see Table A1 in the Appendix. As for program B, the largest difference in cell probabilities is for individuals in the highest income group compared to individuals in the lowest income group. The estimated probability of having zero WTP for program A is 23 percentage points lower for individuals in the highest income group compared to individuals in the lowest income group.

Initially, the distance between the beach and the individuals dwelling was also included as an explanatory variable. In the final estimation of the model the variable was excluded due to insignificant point estimates at a 0.10 significance level.[14]

Based on the result from the regression model, which suggest that the population is relatively homogenous in their valuation of the program (most of the point estimates are insignificant), it seems possible to design a program that generate broad acceptance in the local community. It also seems reasonable to finance the program via the local tax, since individuals with a higher income tend to have a higher valuation of the programs. The local tax in Sweden/Trelleborg amounts to a fixed percentage of the taxable income, which implies that individuals with a higher income will contribute more to the program.

Aggregating the mean WTP from the payment card format over tax payers in Trelleborg resulted in a total welfare estimate of approximately EUR 1.3 million[15] for Program B. Aggregation over households rather than individuals would probably render a lower estimate (Lindhjem and Navrud, 2009). The aggregation should thus be seen as a rough approximation of the total WTP; nevertheless, it indicates the size of the contribution from locals. Accounting for the width of the WTP range (EUR 28) the aggregated upper and lower total welfare estimate is approximately EUR 1.6 million and EUR 1 million. Use of information from the interval width in an benefit-cost analysis (BCA), is also in line with Bohm (1979, 1984) suggestion to use an interval method in BCA for environmental goods.

4. Discussion

Results presented in this study are dependent on the site-specific context. Numerous factors influence the WTP estimate, such as previous experience of valuing the good in question, opinions of the payment vehicle, income levels and so on. Results are therefore not directly applicable to other sites without applying benefit transfer. Nevertheless, they suggest, that locals do value environmental beach programs (that remove algae from beach) and suggest a positive WTP. The payment card and interval open-ended format gave similar results for the level of WTP for the two programs. One should, however, note that the interval open-ended format that was mailed to respondents had a much higher proportion of zero responses than the other two sampling methods. One possible explanation is that the open-ended format is less familiar to respondents, since people are usually more accustomed to reacting to prices than setting them. Stating a zero WTP may thus be an easy way of answering the open-ended question, in situations where one does not use face-to-face interviews. The large scope sensitivity in WTP observed for the programs is not as pronounced for the uncertainty measure, where the width of the stated WTP

[11] A one tailed Man Whitney *U* test indicates a significantly higher WTP from payment card than IOE for program B (Z-Score 1.8088, *p*-value 0.035).

[12] For the demographic variable there is no statistical difference between the samples that answered the questionnaire with the payment card and the sample that answered the questionnaire with the interval open-ended format.

[13] For Program A the adjudted WTP is 38% of the upper bound WTP.

[14] We have also estimated a bivariate ordered probit model to allow for correlations between the stated WTP for program A and B. For this model specification the likelihood function turns out to be flat and the convergence criteria where not reach. The general result is however the same, so the interpretation and policy implications from the univariate estimation do not change. The difference is that the parameter estimates become less significant, which imply that the low heterogeneity that we find in the univariate estimation become even smaller in the bivariate estimation.

[15] As a rough and conservative approximation of the number of municipal tax payers in Trelleborg, we used the number of inhabitants currently working in the age group 20–64 years (24 193).

Table 5
Results from the ordered probit model.

Variable		Program A			Program B		
		Coeff-icient	s.e.	*P*-value	Coeff-icient	s.e.	*P*-value
Constant		−1.17	0.92	0.21	−1.43	0.95	0.13
Year of birth [a]		−0.01	0.01	0.08	−0.01	0.01	0.76
Smell		0.34	0.16	0.03	0.27	0.15	0.08
Smell missing[b]		3.71	2.41	0.12	3.66	3.02	0.23
Gender	Female	0.30	0.31	0.33	0.13	0.29	0.67
	Male	0			0		
Education	Elementary school	0			0		
	High school <3 y.	0.65	0.70	0.35	0.69	0.56	0.22
	High school ≥3 y.	0.77	0.48	0.11	1.30	0.45	0.00
	Higher edu. < 3 y.	0.90	0.48	0.06	1.24	0.48	0.01
	Higher edu. ≥ 3 y.	0.56	0.51	0.27	0.93	0.47	0.05
	Education missing	0.65	0.87	0.46	0.07	0.72	0.93
Income [c]	Lowest	0			0		
	Next lowest	0.65	0.41	0.12	0.12	0.43	0.77
	Middle	0.50	0.44	0.26	0.70	0.39	0.07
	Next highest	0.82	0.45	0.07	0.79	0.44	0.07
	Highest	1.35	0.57	0.02	1.50	0.59	0.01
	Income missing	0.59	0.55	0.29	0.09	0.47	0.85
Threshold parameter	One	0.68	0.25	0.01	0.48	0.23	0.04
	Two	1.45	0.45	0.00	1.06	0.41	0.01
	Three	2.10	0.66	0.00	1.48	0.49	0.00
	Four	2.59	0.82	0.00	2.08	0.57	0.00
	Five	2.97	0.87	0.00	2.56	0.59	0.00
Number of observations		188			200		

Note: The variables gender, education and income are classified by a set of dummy variables. In the table, the reference dummy variable is indicated by a 0 in the coefficient column.
[a] The values for the coefficient and s.e. has been rounded off.
[b] The variable smell missing has a mean value of 0.02.
[c] Income interval: Lowest € 0–1320 per month, Next lowest € 1321–2200 per month, Middle € 2201–3080 per month, Next highest € 3081–3960 per month, Highest more than € 3960 per month.

interval is about the same for both programs.

The finding that not only income but also education was a statistically significant explanatory variable for WTP confirmed results of previous studies of WTP for environmental programs. One example is the study reported by Dorsch (2013), which analyzed data from surveys conducted in 41 countries, including almost 42 000 individuals. The study found that respondents with higher income and higher levels of education were willing to pay significantly more for environmental protection programs than their fellow nationals. In the current study, the finding that age, gender, and distance of residence from the sea did not impact individual WTP in Trelleborg to any large degree is important for policymakers, as it indicates that the benefits of the management strategy do not necessarily have any extensive distribution effects within the coastal community.

The aggregated WTP should be set in relation to costs for the program. Making a bold assumption that the processing associated with biogas recovery could be self-financing in the future,[16] we focused on costs for collecting the biomass from beaches. Based on Blidberg and Gröndahl (2012a), costs for removing the beach-cast from beaches as in Program B[17] would amount to roughly EUR 1 million. However, this estimate is based on a relatively small-scale retrieval focusing on hot spots and easily accessible beach-cast. Thus, the marginal cost can be expected to rise considerably when the most easily accessible biomass have been cleaned. The exact cost for the collection of a future large-scale Program B has not been estimated and depends on variations in the amount of beach-cast, which is controlled by hydrodynamics such as wind and currents. Despite these uncertainties, the fact that estimated non-market benefits are in the same order of magnitude as collection costs is promising.

It is also important to note that increased tourism income from non-locals is not included in the aggregated WTP presented here. Fredriksson and Almström (2012) estimated the turnover from non-local beach-related tourism in Trelleborg to be approximately EUR 14 million for 2011. As mentioned, algae retrieval is predicted to result in an increased beach-visiting frequency for locals. It is reasonable to assume that the same would be true for non-locals, although not included here. If algae retrieval generated a moderate 10% increase in turnover for beach-related tourism by non-locals, this would result in an increase in turnover of EUR 1.4 million annually. This contribution is roughly the same as the contribution from locals.

In short, the results show that the combined benefits of increased algae retrieval in the case study area are potentially substantial. These findings emphasize the importance of considering the non-market values of environmental programs during decision-making and strategy formation in a local or regional setting.

However, non-market benefits, or avoided welfare losses,

[16] Local authorities report a net loss at present due to the custom-designed process and handling system.
[17] The algae in program B would mainly be gathered at sandy beaches and at shallow waters at sandy beaches. However, selective measures would be performed at harbors and at shallow waters alongside stony beaches to remove large accumulations. The gathering would be controlled by algae abundance and focused on hot spot areas with large accumulations.

Table 6
Marginal effects (in percentage units) on the cell probabilities[a] in the payment card for program B. The marginal effect on the cell probabilities is the change in the probability that one will choose a specific alternative (cell) in the payment card due to a change in the explanatory variable by one unit.

	Cell						
	0	1	2	3	4	5	6
Variable	€0	€5.5	€11	€22	€44	€66	≥ €88
Year of birth	0.05	0.01	0.00	0.00	−0.01	−0.01	−0.04
Smell	−5.26	−1.02	−0.48	0.33	1.25	1.23	2.94
Female	−2.44	−0.47	−0.23	0.15	0.58	0.27	1.83
High school <3 years	−11.71	−2.91	−2.22	−0.05	2.25	2.92	11.73
High school ≥3 years*	−20.21	−5.40	−4.77	−1.01	2.75	4.75	23.89
Higher education <3 years*	−19.69	−5.14	−4.40	−0.77	2.92	4.68	22.40
Higher education ≥3 years*	−16.88	−3.66	−2.33	0.46	3.52	4.02	14.87
Next lowest income group	−2.36	−0.48	−0.25	0.13	0.55	0.56	1.84
Middle income group	−12.30	−2.88	−2.02	0.16	2.51	3.03	11.50
Next highest income group	−13.53	−3.32	−2.52	−0.05	2.25	3.35	13.49
Highest income group*	−20.95	−6.23	−6.29	−2.25	1.42	4.52	29.79

*Denotes that the point estimate in the estimated probit model was significant at a 5% significance level.
[a] 1.0 denotes a change in the probability of one percentage point.

should not only be considered in a local or regional setting: to reduce eutrophication and the negative effects of high nutrient loads, it is important to include all losses resulting from eutrophication in policy decisions at national and European levels. In this context, this study adds a piece of information to a larger puzzle, together with previous studies on the topic (e.g. Gren et al., 1997; Söderqvist and Scharin, 2000; Kosenius, 2010).

5. Conclusions

Respondents in the Swedish coastal municipality Trelleborg showed considerable mean WTP for the presented programs. This indicates that expanding and improving the present algae program would be of value for residents. A finding that is important to convey to stakeholders and policy makers, is that the WTP approximation, together with a potential increase in turnover from non-resident beach tourism, amounts to potentially substantial welfare benefits from an extended environmental program. Even though the figures presented here are dependent on the site-specific context, the results imply that suitable coastal environmental programs and strategies may have the potential to realize welfare benefits, or reduce welfare losses, to coastal communities suffering from excessive algae biomass. The WTP estimate may stimulate and motivate similar environmental programs in the future. Furthermore, the results indicate that including non-market values in policy and decision-making may be important for coastal communities in establishing sustainable management strategies.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.ocecoaman.2017.02.009.

Appendix

Table A1
Marginal effects (in percentage units) on the cell probabilities[a] in the payment card for program A. The marginal effect on the cell probabilities is the change in the probability that one will choose a specific alternative (cell) in the payment card due to a change in the explanatory variable by one unit.

	Cell						
	0	1	2	3	4	5	6
Variable	€0	€5.5	€11	€22	€44	€66	≥ €88
Year of birth	0.29	0.05	−0.04	−0.08	−0.08	−0.04	−0.12
Smell*	−7.31	−1.15	0.87	1.95	1.55	1.02	3.07
Female	−6.50	−1.04	0.75	1.72	1.38	0.92	2.77
High school <3 years	−12.59	−3.07	0.23	3.11	3.00	2.15	7.18
High school ≥3 years	−15.03	−3.55	0.33	3.69	3.53	2.53	8.45
Higher education <3 years	−17.23	−4.26	0.12	4.11	4.09	2.99	10.20
Higher education ≥3 years	−11.62	−2.17	0.99	3.02	2.57	1.75	5.46
Next lowest income group	−12.93	−2.84	0.61	3.27	2.99	2.10	6.81
Middle income group	−10.10	−2.08	0.66	2.61	2.30	1.59	5.03
Next highest income group	−15.72	−3.90	0.13	3.78	3.74	2.72	9.24
Highest income group*	−22.61	−7.28	−2.59	4.01	5.48	4.54	18.44

* Denotes that the point estimate in the estimated probit model was significant at a 5% significance level.
[a] 1.0 denotes a change in the probability of one percentage point.

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