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Assessing Non-market Benefits of Seagrass Restoration in the Gulf of Gdańsk

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Cover Page Footnote
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1. INTRODUCTION

Seagrasses are a group of flowering, underwater plants that grow close to the sea shore across the world. As ecosystem engineers and habitat formers they provide important functions to marine ecosystems (Spalding et al., 2003), and contribute to human well-being through a number of benefits they deliver. Seagrass meadows are a nursery habitat for certain fish species (McArthur and Boland, 2006), they attenuate wave energy and thus contribute to coastal defense and erosion control (Fonseca and Cahalan, 1992), and they support water purification and nutrient cycling (Barbier et al., 2011).

In recent decades seagrass meadows have been declining on a global scale. Waycott et al. (2009) estimate global loss of seagrass meadows to be 29% of the known areal extent. Comparisons with other marine ecosystems (Boström et al., 2011), such as mangroves (degraded at 35%), coral reefs (34%), saltmarshes (13-30%) and oyster reefs (85%), indicate that seagrass meadows belong to the most threatened marine ecosystems on the planet. What is even more threatening for this ecosystem is that seagrass has the highest annual loss rate (7%), together with coral reefs (4-9%; Boström et al., 2011). This degradation is the direct result of human activities. Coastal development, overfishing, eutrophication, dredging, decreasing water quality and climate change are the drivers that have the greatest negative impacts on seagrass (Waycott et al., 2009 and Boström et al., 2011). Regional studies for the Baltic Sea and North East Atlantic (Boström et al., 2003, 2014) confirm that areas covered by seagrass follow the worldwide trend and are diminishing significantly. Although these studies focus on seagrass ecology, they underline the relationships between socioeconomic and ecological systems. Therefore, they call for actions to improve public recognition of this highly threatened habitat and identify economic valuation as one of the tools to better inform environmental policy and management.

In Europe the seagrass protection framework is built around European legislation that includes the Habitats Directive (92/43/EEC), the Water Framework Directive (2000/60/EC), the Nitrates Directive (91/676/ EEC) and the Marine Strategy Framework Directive (2008/56/EC). This framework is complemented with international agreements – such as HEL-COM in the Baltic Sea – and national environmental legislation (Boström et al., 2014). Nonetheless, the existing protection practices suffer from serious drawbacks, one of them being the scarcity of quantification and (economic) valuations of benefits provided by seagrass to support ecosystem-based management (Boström et al., 2014). Although such studies naturally exist, they are spread world-wide, concern various geographical regions and use various assessment scales. Some of the most recent assessments deal with (i) the provision of nursery habitats for commercial fish species (McArthur and Boland, 2006 and Bertelli and Unsworth, 2014), (ii) protection of the coast against erosion (Fonseca and Cahalan, 1992), or (iii) water purification and nutrient cycling (Barbier et al., 2011 and Cullen-Unsworth et al., 2014). Other studies investigate the contribution of seagrass to carbon sequestration (Macreadie at al., 2014) and tourism and recreation (Cullen-Unsworth et al., 2014). The lack of holistic studies is even more evident in the Baltic Sea region. Rönnbäck et al. (2007) provide perhaps the most detailed information on ecosystem services provided by seagrass meadows in the Baltic, yet the valuation is rather qualitative than quantitative, and does not focus exclusively on *Zostera marina* meadows.

To address the need for economic valuations of the benefits provided by seagrass meadows (e.g. Barbier et al., 2011 and Boström et al., 2014) the aim of the present study is to assess the benefits arising from a seagrass restoration program implemented at the coast of the Baltic Sea in Northern Poland employing the discrete choice experiment (DCE) approach (Hanley et al., 1998, Louviere et al., 2000 and Kanninen, 2006). This survey-based technique is used to value a set of the non-market benefits of an expansion of seagrass meadows in the Gulf of Gdańsk. The study has three interlinked objectives:

(1) assess the level of public concern and support regarding the conservation of seagrass meadows in the Gulf of Gdańsk;
(2) assess the values of different non-market environmental consequences of the expansion of seagrass meadows;
(3) identify the determinants of preferences for these environmental consequences.

The study will also discuss to what extent values elicited within it can be mapped to underlying ecosystem services to facilitate their use in value transfer and environmental management.

2. THE ECONOMIC VALUATION OF BENEFITS RELATED TO SEAGRASS

In the economic valuation of seagrass most attention has been on its direct contribution to the production of marketable outputs. Numerous studies apply the production function approach to value the input of seagrass into fisheries. Anderson (1989) for instance develops a simple model to estimate the benefits of seagrass restoration in terms of its contribution to hard-shell blue crab production in Virginia. Other studies assessing the value of seagrass meadows for fisheries include McArthur and Boland (2006), Unsworth et al. (2010), Blandon and zu Ermgassen (2014), Tuya et al. (2014). Vassallo et al. (2013) assess the value of ecosystem services of *Posidonia oceania* in the Mediterranean. Again using the production function approach they value the contribution of seagrass to fisheries nurseries, coastal erosion prevention, primary production and oxygen release.

When it comes to benefits of the coastal environment that are not traded in markets, the contingent valuation method (Carson and Hanemann, 2005) has been used to value changes in water quality (Freeman, 1995) and environmental damage caused by eutrophication (Le Goffe, 1995 and Markowska and Żylicz, 1999). Despite the lack of stated preference studies focusing exclusively on seagrass, a considerable number of studies value one or more of the non-market benefits investigated in the present study. Several DCE studies have valued different aspects of water quality. Hanley et al. (2003) use contingent and real behavior to assess the value of coastal water quality improvements for bathing in Scotland. Actual and hypothetical numbers of trips to beaches are elicited for different levels of water quality. The authors then calculate the monetary value of water quality improvements through employing a fixed cost per mile of travel. A DCE study by Eggert and Olson (2009) focuses on valuing water quality and its impact on fishing, bathing opportunities and biodiversity conservation in Sweden. Can and Alp (2012) conduct a DCE to value water quality improvements resulting from a marine protected area at the Mediterranean coast of Turkey. They find no difference in willingness to pay (WTP) for reductions in health risk from the water and for the protection of marine life between tourists and local residents. Hynes et al. (2013) also employ a DCE to value different aspects of water quality changes based on the EU Bathing Water Directive. Their results show significant WTP of active water users, such as swimmers and kayakers, for increased health of the seabed and related increased probability to spot rare animal species, lower risk of stomach and ear infections and more thorough debris collection on beaches. The DCE study by Taylor and Longo (2010) assesses the value of improvements in coastal water clarity resulting from reduced algal blooms in Bulgaria. Focusing only on the recreational use of coastal waters, the study finds significant WTP for improved water clarity, shorter duration of blooms and less congested coastal waters.

Regarding the recreational value of coastal ecosystems, the valuation literature has mainly focused on beach characteristics, such as quality (Loomis and Santiago, 2013) or access and width (Whitehead et al., 2008). A limited number of studies measure the value of underwater habitats for recreational use. The DCE by Wielgus et al. (2003) assess the recreational value of coral reefs in Israeli waters of the Red Sea. Their results show that divers are willing to pay for more species diversity in the reefs and for better visibility in the water. Chen et al. (2013) use the travel cost and contingent valuation methods to assess recreational benefits on and around artificial reefs in Taiwan. To the best of our knowledge, stated preference methods, and DCE in particular, have thus far not been directly applied to seagrass restoration. This study aims to fill this gap in the valuation literature.

3. METHODS

3.1 Case Study Description

The Gulf of Gdańsk stretches from the northern part of the Pomeranian Province in Poland to the coast of the Kaliningrad Oblast in Russia (Figure 1). It has been subject to intensive anthropogenic pressures and relatively strong conflicts between various users (mainly tourism, fishing and shipping) especially in its most sheltered part, Puck Bay. The region is under the influence of the Tri-city metropolitan area comprised of Gdańsk, Gdynia and Sopot, with a total population of over one million people. The western and eastern regions of the Gulf are protected as NATURA 2000 sites and HELCOM Baltic Sea Protected Areas. A part of the Gulf (the Inner Puck Bay) is additionally managed within the coastal Landscape Protection Park.

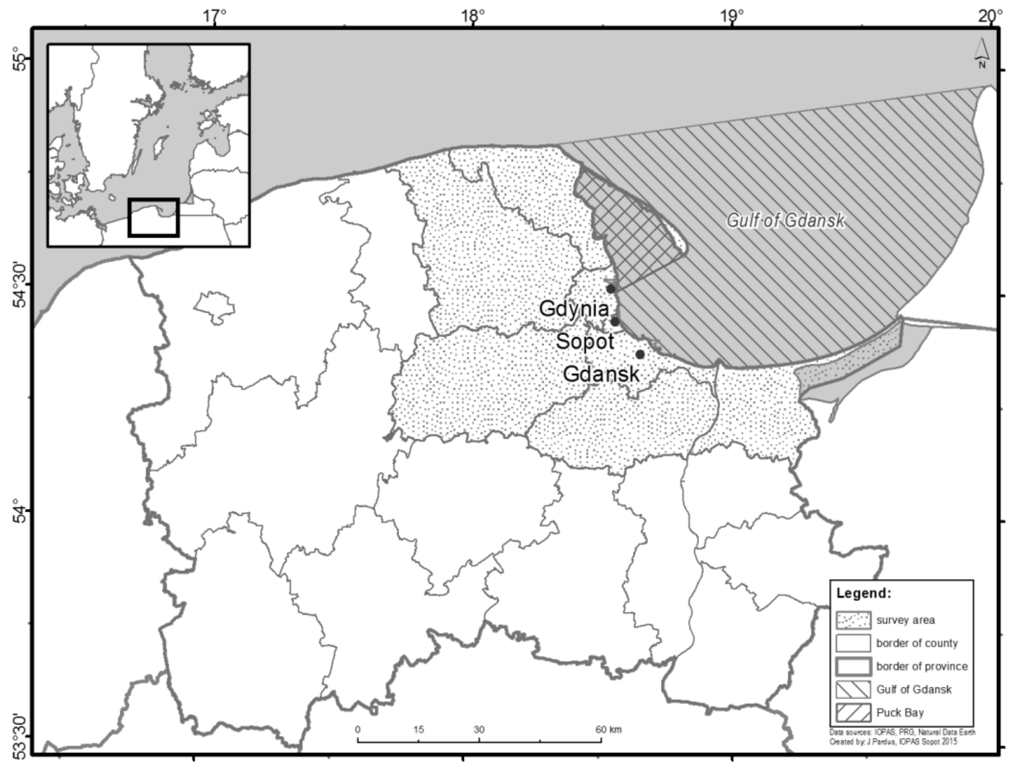

Figure 1. Map of the Gulf of Gdańsk and the survey area

One of the most important habitats in the Gulf of Gdańsk, and in Puck Bay in particular, are underwater meadows of seagrass (*Zostera marina). Zostera* was abundant in this area in depths of up to 10 meters until the 1950s (Boström et al., 2003). During the following thirty years the area covered by seagrass decreased due to deteriorating water quality and increased eutrophication (Jankowska et al., 2014). In 1969 the seagrass covered 5,120 ha but had fallen to only 6% of that area in 2007. Resulting from improved water quality and restoration efforts, *Zostera marina* is currently regaining lost territory, although neither the scale nor the durability of this restoration are well documented (Jankowska et al., 2014).

3.2 Development of the Valuation Scenario, Choice Attributes and Questionnaire

In DCE surveys, respondents are presented with hypothetical environmental programs ('scenarios'), which will lead to changes in certain aspects of a non-market good or service described in these scenarios. This description includes some background information as to how the anticipated change is caused. The scenario explains that the environmental program can only be implemented at a certain cost, which will have to be borne by those benefiting from the expected improvements. In the subsequent choice tasks respondents are required to indicate their preferred option from a set of environmental management measures. The choice options are described by a set of choice attributes specifying the effects that the hypothetical management measures will have. Typically, one choice attribute is the cost to the respondent of implementing the proposed measures. Consequently, the value respondents attach to the different attributes can be inferred from their stated choices and expressed as their WTP. These WTP estimates are indicators of the change in well-being respondents expect from the various aspects of the management program described in the respective choice attributes.

Questionnaire design for this study started with a number of semi-structured interviews conducted with members of the public ($N = 19$) in the Tricity metropolitan area. The interviews were followed by three focus group meetings in Gdańsk and Sopot, during which members of the public discussed the way and extent in which seagrass can affect their well-being. This process resulted in the selection of the choice attributes to be used in the survey. The selection was based on the perceived importance of discussed functions, and perceived relationships with individual welfare. The choice attributes and their descriptions in the main survey were further discussed with seagrass experts. The final descriptions were tested in two pilot surveys ($\mathrm{N} = 50$ each) conducted in person with members of the public in the Tri-city metropolitan area. After each pilot survey the questionnaire was modified based on findings to ensure comprehensibility for respondents. Table 1 presents the attributes, their respective descriptions and levels.

The first attribute of the hypothetical seagrass restoration program, algae reduction, has three levels. In the current situation there are about 30,000 tons of filamentous algae (*Ectocarpus* and *Pilyaella*) in the Gulf per year (Węsławski et al., 2013 and J. Wiktor and J.M. Węsławski, pers. comm.), which means that these algae can be found everywhere in the water and are also washed up on the beach. Extended seagrass meadows could decrease the amount of algae in the water to 10,000 tons or even 1,000 tons annually. A reduction to 10,000 tons would mean that there are practically no algae on the beach and a limited amount in near-shore waters, whereas 1,000 tons of algae means that a visitor has

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practically no chance to see algae in the water. To reach the targets set in the first (and second) scenario, the area covered by the seagrass meadows should at least be doubled (and expand four-fold).

Table 1. Choice Attributes (Status Quo in Italics)

Attribute	Description	Levels
Algae reduction	Annual amount and spread of green algae in the Gulf (*Ecosystem service: Biological control*)	*30,000 tons (Algae in the whole Gulf)*, 10,000 tons (No algae close to the shore), 1,000 tons (No algae at all)
Access to seagrass	Access to areas with submerged seagrass for boating and diving (*Ecosystem service: Recreation and tourism*)	*Access allowed,* access forbidden
Water clarity	Depth of the seafloor still visible from the surface (*Ecosystem service: Water purification*)	*2m*, 4m, 6m
Cost	Additional cost to be paid in form of a waste water treatment fee by every household to fund the seagrass extension program	*zł 0*, zł 20, zł 30, zł 50, zł 90, zł 150

The second attribute, direct access to seagrass, captures the potential for recreational use. The entire Gulf and especially Puck Bay are very important for seaside tourism and are partially covered by nature protected areas. Therefore, a number of regulations limiting tourist activities have recently been introduced. These restrictions may influence users' well-being and raise high public concern over access rights, which was discussed in detail during focus group meetings. Based on these discussions, the second attribute was designed to capture the trade-off between opening (for recreation) and closing seagrass meadows (for preservation). Consequently, the direct access attribute has two levels: Access to areas where seagrass is growing for boating and diving can either be allowed (the current situation) or forbidden.

The potential of seagrass meadows to improve water clarity was selected as the third choice attribute. By utilizing dissolved nutrients and filtering other small particles from the water through the animal community associated with seagrass, the presence of meadows makes the water clearer and more transparent (Lee and

Dunton, 1999 and Hemminga and Duarte, 2000). There are several ways to convey differences in water clarity to respondents in stated preference surveys. This study follows the approach by Taylor and Longo (2010) and employs visibility of the sea floor at varying water depths as an indicator of water clarity. In the current situation, it is possible to see the bottom of the Gulf at 2 meters water depth. With improved water clarity, it will be possible to see it at depths of four and six meters (Levin et al., 2013 and S. Sagan and J.M. Węsławski, pers. comm.).

The last attribute is the cost of the hypothetical seagrass management program which provides the overall framework of the choice experiment in the survey. Focus group participants favored the creation of a special fund to which all residents of the province would have to contribute a certain amount as a way of financing such an effort. The valuation scenario further specifies that contributions would have to be made in form of a waste water treatment fee paid annually for the next 10 years. While the current situation comes at no cost to the respondent, the alternative management programs have a positive cost equal to one of the cost levels shown in Table 1.

While algae reduction and water clarity improvements through seagrass meadows might be related, these attributes can change independently under the influence of other environmental factors such as unicellular algae blooms, river inflows, agricultural use of nutrients or changes in species compositions. Therefore, algae reduction and improvement of water clarity were varied independently across choice tasks. Such possible relationships did not raise any concern over plausibility of the choice scenarios during the focus groups discussions and pilot surveys. Results from the second pilot served to inform the experimental design of the main survey. Coefficients of the influence of the choice attributes on choices were computed applying a mixed logit model (cf. Section 3.3) to the choice data. These coefficients were used as priors when creating a Bayesian D-efficient design (Scarpa and Rose, 2008) in the software package Ngene (ChoiceMetrics, 2012). The experimental design was restricted to exclude policy options that yield the status quo for each attribute at positive cost, since this option would be dominated by the status quo. A sample choice card is shown in Figure 2.

The final set includes twelve choice tasks separated into three blocks. Respondents are randomly allocated to one block and only complete the four

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choice tasks in that respective block. Each choice task contains two alternative management programs at different cost levels and a 'no change' or status quo option at zero cost.

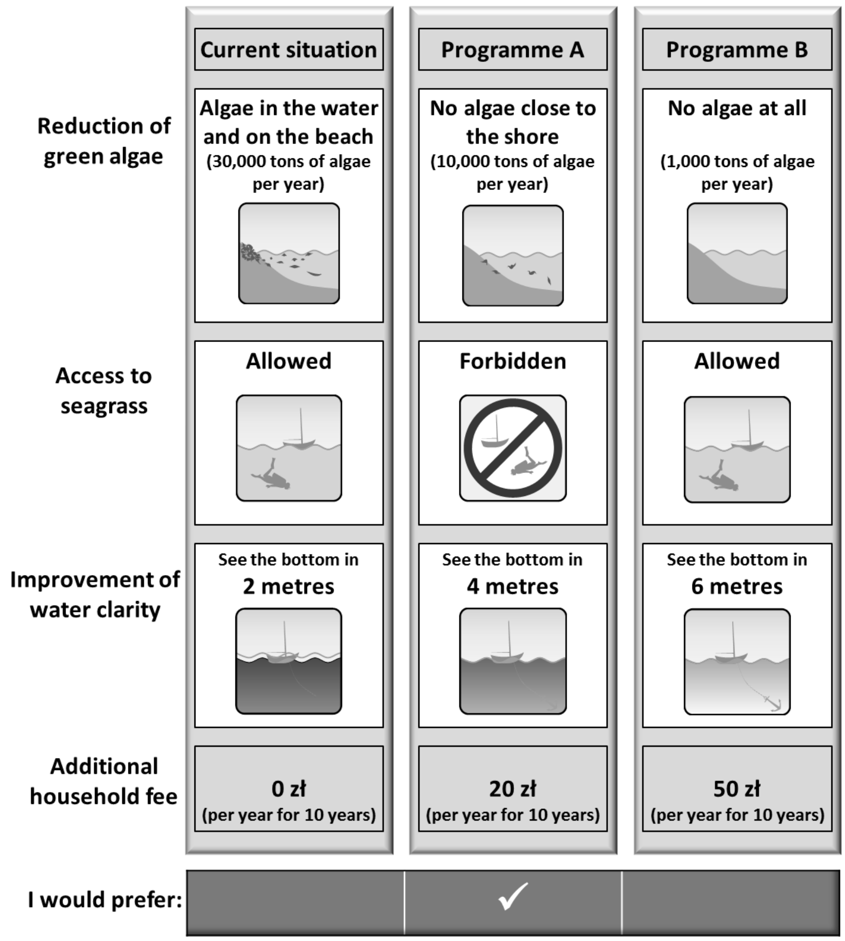

Figure 2. English translation of a choice card (cards in questionnaire were in color).

The final questionnaire consists of four parts. Part one contains some questions pertaining to the respondent's general knowledge of and experience with the Gulf of Gdańsk, and seagrass in particular. Part two introduces the valuation framework and the hypothetical seagrass restoration program. This includes the description of the choice attributes and the mode of payment (Table 1). Part three contains the actual choice experiment as well as several debriefing questions regarding choice certainty, and whether the respondent considered all or just some choice attributes when making her choices. It also contains a set of attitudinal questions to identify protest respondents. Part four has a series of attitudinal and socio-demographic questions, which are needed to characterize potential subgroups of respondents who exhibit differing valuations of the choice attributes.[1]

3.3 Econometric Analysis of Choice Data

Basis for the analysis of the resulting choice data is the random utility model (RUM) (McFadden, 1974), which allows for the use of conditional and mixed logit models (Train, 2009). Assume respondent n obtains utility U_{njt} from choosing option i out of a set of options $j = 1, \ldots, i, \ldots, J$ in choice situation t according to

$$U_{nit} = \beta_n{}' x_{nit} + \varepsilon_{nit}. \quad (1)$$

x_{njt} denotes a vector of attribute characteristics of option i with a coefficient vector β_n. If the random component of utility, ε_{nit}, is assumed to follow a type I extreme value distribution, the probability P_{nit} of respondent n choosing alternative i rather than any other alternatives $j \neq i$ in choice situation t is

$$P_{nit} = \frac{exp(\beta_n{}' x_{nit})}{\sum_{j=1}^{J} exp\left(\beta_n{}' x_{njt}\right)}. \quad (2)$$

In the conditional logit model it is assumed that coefficient vector β_n is constant across respondents, and therefore only $\beta_n = \beta \ \forall n$ is estimated. The elements of β can be interpreted as the average utility weights of the attributes included in the choice tasks. The mixed logit model allows for the coefficient vector to vary over respondents by specifying its components as random variables. Consequently, the mixed logit model can account for random (i.e. unexplained) heterogeneity of preferences. In this study the coefficients of every attribute but cost are assumed to be normally distributed.[2] While the conditional logit can be fitted using traditional maximum likelihood, the mixed logit model

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[1] The questionnaire is available from the authors on request.

[2] Other distributional forms could be assumed for the choice attribute coefficients but it is not clear *a priori* which sign of the coefficients can be expected in this study. Hence it was decided to apply the most commonly used normal distribution. Since, on the contrary, it can be expected that the cost coefficient will be negative, it is assumed to be fixed across respondents.

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relies on simulated maximum likelihood estimation with 1,000 Halton draws. In both models, respondent-specific variables can be interacted with attribute-specific variables to account for differences in preferences between (groups of) respondents (Train, 2009). WTP for a particular attribute k can be calculated as

$$WTP_k = -\frac{\beta_k}{\beta_{cost}} \quad (3)$$

where β_k and β_{cost} denote the coefficients of the k-th attribute and of the cost attribute, respectively. When the mixed logit model is used β_k represents the mean of the distribution of the coefficient of the k-th attribute.

4. RESULTS

4.1 Sample Characteristics and Knowledge about Seagrass

The main survey was administered between November 2013 and January 2014. Professional interviewers conducted the survey interviews face-to-face in respondents' homes. Survey respondents were sampled from the resident population of eight counties and municipalities close to the Gulf of Gdańsk (Figure 1).[3] 500 completed questionnaires were collected. The goal was to interview a representative sample of the resident population of this area so as to include potential users and non-users of the Gulf. Table 2 displays descriptive statistics of certain socio-demographic variables. The sample means of those variables closely reflect means of official data (right-hand column of the table). Given this resemblance, the sample can be considered to reflect the structure of the underlying resident population.

The first part of the questionnaire includes questions about respondents' knowledge of and experience with the marine environment in general, and seagrass in particular. Respondents are apparently very familiar with the Gulf of Gdańsk as only 6% indicate they never go to the seaside, and only 8.8% state that they never engage in any recreational activity on the seashore. As to the environmental situation in the Gulf of Gdańsk, there is no clear picture to be found in the responses. While 29% of respondents think the situation has

[3] These include: Gdański, Kartuski, Nowodworski, Pucki and Wejherowski counties as well as the cities of Gdynia, Gdańsk and Sopot.

improved over the last two decades, 28.4% state that it has in fact deteriorated. This finding is reflected in responses to the subsequent question, where 51.8% of respondents rate the overall state of the environment in the Gulf as 'good' but 32.4% judge it as 'poor'. Only 1.6% and 2.8% find it to be 'very good' or 'very poor', respectively.

Table 2: Means, Shares and Standard Deviations of Socio-demographic Variables

	Survey sample			Resident population (mean) [a]
	N	**Mean/share**	**Std. dev.**	
Age (years)	492	44.34	16.23	46 [b]
Male (share)	500	0.48	0.50	0.48 [b]
Household size (members)	498	3.13	1.71	2.90
Monthly household income (PLN)	317	3799.69	2690.84	- [c]
Level of education (share)				
Primary school	498	0.10	-	0.11 [b]
Vocation school	498	0.17	-	0.16 [b]
Secondary school	498	0.54	-	0.54 [b]
Bachelor degree or higher	498	0.19	-	0.19 [b]

[a] data retrieved from http://www.stat.gov.pl/, [b] data from 2011, [c] data not available

Regarding the seagrass meadows, 35.2% of respondents had heard about seagrass meadows before the survey. Of these respondents, 36% had actually seen the seagrass on the bottom of the Gulf (12.7% of the total sample). When asked if they thought protecting the seagrass is worthwhile, exactly half of all respondents support this idea, whereas 48% are undecided (either need more information or simply don't know). Only 2% of respondents think that it is not worthwhile to protect the seagrass meadows. As for the perception of the state of the environment in the Gulf, public opinion regarding seagrass meadows seems to be as divided.

4.2 WTP for Seagrass Benefits

The sample on which the analysis of choice tasks is based consists of 413 respondents after 87 cases were removed as protest respondents. These are respondents who chose the costless status quo option in all four choice occasions and agreed to the statements: (i) "Taxes and fees are already too high, so there should not be an additional financial burden", (ii) "I already pay enough for other things", (iii) "It is my right to have well preserved seagrass meadows and I should

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not have to pay extra for it" and (iv) "The local government should cut public spending on other things instead of expecting a contribution from me". Table 3 reports conditional and mixed logit models to identify how the attributes affect choices. In the conditional logit model the attributes ALGAE10, ALGAE1 and CLARITY influence choices positively, i.e. the probability that a policy option is chosen increases with the respective presence of the attribute level. The fact that access to seagrass is forbidden (NO_ACCESS) and the level of the cost attribute (COST) affect choice probability negatively as expected. The coefficient of the alternative-specific constant indicating the change options (as opposed to the status quo), ASC_CHANGE, is significantly positive. This indicates that regardless of the respective level of the four choice attributes, on average respondents prefer a change option over the status quo.

The mixed logit model yields some coefficients that differ in magnitude but all point into the same direction as in the conditional logit model. In this model a reduction of algae in the Gulf to 1,000 tons (ALGAE1) has a stronger effect on choices than a reduction to just 10,000 tons (ALGAE10). For the mixed logit model, standard deviations of the estimated coefficients of the non-monetary attributes are reported, too, because this model relaxes the assumption that preferences are constant across respondents. The model does not find random preference variation for a reduction of algae in the Gulf as standard deviations of ALGAE10 and ALGAE1 are insignificant. It does, however, detect heterogeneous preferences for access to seagrass (NO_ ACCESS) and water clarity (CLARITY), as well as the ASC_CHANGE. These findings are evidence of substantial random preference heterogeneity. Consequently, only the mixed logit model was employed to identify choice determinants in the following analysis.

Table 3 also reports WTP estimates for all non-monetary attributes. In general, WTP estimates computed by means of the conditional and the mixed logit model are very similar. The main difference, in the WTP for a reduction of green algae in the Gulf to 10,000 tons per year (ALGAE10), will be discussed below. Respondents are willing to pay €14.48 (€12.13 in the conditional logit)[4] per year and household to reduce the total amount of green algae in the Gulf from 30,000 tons to 10,000 tons annually, which implies some algae left in the water but none close to the shore. There is a slightly higher WTP of €15.63 (€15.49) for

[4] In the survey, amounts were stated in Polish Złoty (PLN). For the analysis amounts were converted into Euros at the exchange rate of €1 = PLN4.15 at the time of the survey.

a reduction of algae to 1,000 tons annually, which means that virtually no algae can be found anywhere in the water. The 95%-confidence intervals of WTP estimates reported in the table overlap for ALGAE10 and ALGAE1, therefore the differences in WTP are not significant.

Table 3. Conditional and Mixed Logit Models and WTP Estimates

	Conditional logit model		**Mixed logit model**	
	Coefficient	**WTP (€)**	**Coefficient**	**WTP (€)**
Mean of coefficients				
ASC_CHANGE	0.455**		1.685**	
	(0.113)		(0.261)	
ALGAE1	0.355**	12.13	0.435**	15.63
	(0.113)	[2.44-21.82]	(0.144)	[6.60-24.67]
ALGAE10	0.278*	15.49	0.412**	14.48
	(0.116)	[6.69-24.29]	(0.138)	[5.17-24.50]
NO_ACCESS	-0.400**	-17.47	-0.499**	-17.95
	(0.084)	[-26.01- -8.93]	(0.114)	[-26.85- 9.05]
CLARITY	0.078**	3.41	0.087**	3.12
	(0.022)	[1.57 – 5.26]	(0.029)	[1.15 -5.09]
COST	-0.023**		-0.028**	
	(0.004)		(0.004)	
Standard deviation of coefficients				
ASC			3.333**	
			(0.299)	
ALGAE1			0.127	
			(0.767)	
ALGAE10			0.020	
			(0.422)	
NO_ACCESS			0.815**	
			(0.174)	
CLARITY			0.250**	
			(0.042)	
Log-likelihood	-1,766		-1,526	
Observations	4,956		4,956	
Halton draws	-		1,000	
Parameters	7		13	
Adjusted ρ^2	0.005		0.137	

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NOTES ON TABLE 3

** and * indicate 1%- and 5%-level of confidence. Standard errors in parentheses. WTP 95%-confidence intervals in brackets, obtained using the bootstrap method in Krinsky and Robb (1986) with 1,000 draws. Adjusted ρ^2 is computed as $\rho^2 = 1 - (LL_m - k)/LL_0$, where LL_m and LL_0 are the log-likelihoods of the full model, and the intercept-only model respectively, and k the number of parameters. Bayesian Information Criterion (BIC) is calculated as $BIC = -2LL_m + k \cdot \ln(N)$ with N denoting the number of respondents. The use of BIC is preferred to Akaike Information Criterion because it imposes a stronger penalty on the inclusion of more parameters in the model. The Stata command 'mixlogit' occasionally produces standard deviation estimates with a negative sign. These have been corrected as they are to be interpreted as being positive (Hole 2007).

BIC	3,565	3,113

The highest WTP in relation to the other attributes is estimated with respect to access to the seagrass. On average respondents have a WTP of €-17.95 (€-17.47) for a closure of boating and diving around the seagrass meadows, which indicates a significant loss in utility caused by this change. The third choice attribute, water clarity, is treated as a continuous variable and WTP for this attribute is calculated as a per-meter increase of sight of the bottom from the surface of the water. The model yields an estimated mean WTP of €3.12 (€3.41) annually for each additional meter from which the bottom of the Gulf can be seen through the water. Recalling that according to the valuation scenario, in the current situation the bottom can be seen from two meters and that the largest possible change is six meters, such an improvement of four meters is valued at €12.48 (€13.64). These figures fall into the range of WTP estimates for the other attributes. These (annual) WTP figures stated through respondents' choices represent between 0.028% and 0.164% of reported annual household income.

4.3 Determinants of Preferences

To identify variables that systematically affect respondents' choices, two additional mixed logit models were run and reported in Table 5. Coefficients of the non-monetary attributes are similar to those in the basic models in Table 3. Respondents prefer a reduction of algae in the water, and a greater reduction (ALGAE1) more strongly than a smaller reduction (ALGAE10). Respondents also have clear preferences against access restrictions to seagrass (NO_ ACCESS) and for improvement in water quality (CLARITY). The coefficient of COST is again negative and highly significant.

In terms of respondent-specific effects on choices, model 1 contains a set of demographic variables and model 2 includes additional variables pertaining to the use of and attitude towards the marine environment. All of these variables are interacted with ASC_CHANGE (Table 4). Respondent age has a negative effect (AGE), which means that older respondents are more likely to reject any management plan and prefer the no-change option. This effect, however, is not linear, as indicated by the significantly positive effect of age squared (AGE_ SQ). The age where this negative effect turns into a positive effect is at 54 years in the first and 51 years the second models in Table 5.[5] Middle-aged respondents are therefore least likely to endorse any seagrass management plan that involves a cost to their household.

[5] This is calculated by solving $\frac{\partial f(AGE)}{\partial AGE} = \frac{\partial\left(\beta_{AGE} \cdot AGE + \beta_{AGE_{SQ}} \cdot AGE^2\right)}{\partial AGE} = 0$ for AGE, where β_{AGE} and $\beta_{AGE_{SQ}}$ are the estimated coefficients for age and age squared, respectively.

Table 4. Description of Variables Used in the Regression Models (after discarding protest respondents)

Variable	Description	N	Mean
Variables specific to the choice alternative			
ASC_CHANGE	Alternative-specific constant (0 = No-change option, 1 = management plan B or C)		
ALGAE10	Reduction of algae to 10,000t per year, no algae close to the shore [a]		
ALGAE1	Reduction of algae to 1,000t per year, virtually no algae in the water [a]		
NO_ACCESS	Access to seagrass for boaters and divers forbidden [a]		
CLARITY4	Seafloor is visible at 4 meters water depth [a]		
CLARITY6	Seafloor is visible at 6 meters water depth [a]		
COST	Cost of the seagrass expansion program as waste water treatment fee in PLN		
Variables specific to the respondent		**N**	**Mean**
AGE	Age of the respondent in years	405	43.63
AGE_SQ	Age squared	405	2,171.53
MALE	Gender of the respondent [a]	413	0.47
SECSCHOOL	Respondent has graduated from secondary school [a]	411	0.76
INCOME	Monthly household income of the respondent in 1,000 PLN	263	4.03
CHILDREN	Number of children of the respondent	410	1.30
HHSIZE	Number of household members	411	3.11
IN_SEA	Respondent has taken part in recreational activities in the sea [b]	413	0.36
ON_SEA	Respondent has taken part in recreational activities on the sea [b]	413	0.12
BY_SEA	Respondent has taken part in recreational activities by the sea [b]	413	0.76
PROTECT	"Do you think that seagrass meadows should be protected in the Gulf of Gdańsk?" [c]	413	0.50
EXPAND	"Do you think it is worthwhile to expand the area in the Gulf of Gdańsk covered by seagrass meadows above the current size?" [c]	412	0.34
GOOD_ENV_SIT	"How do you judge the overall state of the environment in the Gulf of Gdańsk today?" [d]	369	2.59

[a] Dummy variable (1 = yes, 0 = no); [b] Dummy variable (1 = Sometimes or often, 0 = Rarely or never); [c] Dummy variable (1 = Yes, 0 = No, Don't know or I need more information); [d] Ordinal variable (4 = Very good, 3 = Good, 2 = Poor, 1 = Very poor)

In addition, the number of children of the respondent (CHILDREN) and household income (INCOME) positively affect the likelihood of preferring a seagrass management plan to the current situation. Household size as measured by number of household members (HHSIZE) affects this likelihood negatively. Larger households are therefore more likely to prefer the costless status quo than households with fewer members. The gender (MALE) and level of education (SECSCHOOL) of the respondent do not have any effect on choices.

In model 2, a similar pattern of effects of the demographic variables can be found. Only household size is not significant at the 1%-level of confidence when additional variables are added to the model. Regarding the use of the marine environment, the frequency of recreational activities on the seashore (BY_SEA) is significantly positive, indicating that those who use the beach and the seaside more often are more likely to support the seagrass restoration program. The frequency of activities in (IN_SEA) and on the water (ON_SEA) do not have a significant effect on choices between the no-change option and the restoration programs.

Table 5. Mixed Logit Models to Identify Respondent-Specific Determinants of Choices

	Model 1			Model 2		
	Coefficient		Std. Err.	Coefficient		Std. Err
Mean of random coefficients						
ASC_CHANGE	8.236	**	(2.649)	8.233	**	(2.937)
ALGAE10	0.498	**	(0.188)	0.605	**	(0.199)
ALGAE1	0.665	**	(0.202)	0.747	**	(0.213)
NO_ACCESS	-0.541	**	(0.161)	-0.486	**	(0.167)
CLARITY	0.085	*	(0.039)	0.089	**	(0.039)
Standard deviation of random coefficients						
ASC_CHANGE	3.276	**	(0.384)	2.830	**	(0.373)
ALGAE10	0.413		(0.716)	0.381		(0.788)
ALGAE1	0.048		(0.606)	0.008		(0.451)
NO_ACCESS	0.949	**	(0.225)	0.950	**	(0.223)
CLARITY	0.272	**	(0.056)	0.230	**	(0.059)
Fixed coefficients						
COST	-0.038	**	(0.007)	-0.041	**	(0.007)
AGE [a]	-0.350	**	(0.117)	-0.338	**	(0.117)
AGE_SQ [a]	0.003	**	(0.001)	0.003	**	(0.001)
MALE [a]	-0.141		(0.538)	-0.561		(0.539)
SECSCHOOL [a]	0.505		(0.639)	0.430		(0.633)
INCOME [a]	0.355	**	(0.104)	0.353	**	(0.106)
CHILDREN [a]	1.032	**	(0.311)	0.981	**	(0.307)
HHSIZE [a]	-0.500	**	(0.190)	-0.415	*	(0.183)
IN_SEA [a]				0.222		(0.288)
ON_SEA [a]				-0.293		(0.372)
BY_SEA [a]				0.712	*	(0.306)
PROTECT [a]				1.398	*	(0.665)
EXPAND [a]				1.164		(0.742)
GOOD_ENV_SIT [a]				-1.161	*	(0.479)
Log-likelihood	-919			-786		
Observations	3,108			2,712		
Halton draws	1,000			1,000		
Parameters	18			24		
Adjusted ρ^2	0.165			0.168		
BIC	1,931			1,693		

NOTES TO TABLE 4
** and * indicate 1%- and 5%-level of confidence. [a] interacted with ASC_CHANGE. Adjusted ρ^2 is computed as $\rho^2 = 1 - (LL_m - k)/LL_0$, where LL_m and LL_0 are the log-likelihoods of the full model, and the intercept-only model respectively, and k the number of parameters. Bayesian Information Criterion (BIC) is calculated as $BIC = -2LL_m + k \cdot \ln(N)$ with N denoting the number of respondents. The use of BIC is preferred to Akaike Information Criterion because it imposes a stronger penalty on the inclusion of more parameters in the model. The Stata command 'mixlogit' occasionally produces standard deviation estimates with a negative sign. These have been corrected as they are to be interpreted as being positive (Hole 2007).

Turning now to the effects of some attitudinal variables on choices, the model shows that respondents who believe that the seagrass meadows should be protected (PROTECT) are more likely to choose a management option. This effect cannot be found for respondents who support an expansion of the seagrass meadows in the Gulf (EXPAND). However, the lack of significance of this coefficient might stem from the fact that these variables are highly correlated ($r = 0.649, p < 0.001$) and hence the model fails to accurately distinguish between the influences of these variables. This was tested in a separate model excluding PROTECT, which is not presented for the sake of brevity but which showed a significantly positive coefficient of EXPAND. The fact that respondents judge the environmental situation of the Gulf of Gdańsk to be 'good' or 'very good' rather than 'poor' or 'very poor' leads to a lower WTP for the seagrass attributes, as indicated by the negative coefficient of (GOOD_ENV_STATUS). Those respondents who perceive the environmental situation to be good are less likely to prefer any of the restoration programs involving an additional cost to their households.

In the standard deviation section of Table 5 the estimates of the standard deviations in models 1 and 2 show the same pattern as in the basic model in Table 3. Even after including different interactions in the model there is still a substantial amount of random heterogeneity of preferences for NO_ACCESS, CLARITY and ASC_CHANGE. Preferences regarding the reduction of algae in the water (ALGAE1 and ALGAE10), however, do not show significant random heterogeneity across respondents. Comparing across models, standard deviation of ASC_CHANGE decreases the more interactions are included in the model because more inter-respondent heterogeneity is explicitly accounted for by these interactions.

The overall fit to the data of both models exceeds that of the conditional logit and the basic mixed logit models in Table 3. The higher log-likelihood and McFadden's adjusted ρ^2, as well as the lower value of the Bayesian Information Criterion (BIC), indicate that the inclusion of respondent-specific variables improves the predictive power of the model. Of the models in Table 5, the more extensive model 2 exhibits a better fit to the data. This is confirmed by a likelihood ratio test for which model 1 was computed with the same number of cases as model 2. The test statistic is significant $\chi^2_{test} = -2 \cdot (LL_{model1} - LL_{model2}) = -2 \cdot [-918.98 - (-786.29)] = 265.38, (p < 0.001)$ indicating that model 2 outperforms model 1 in terms of fit to the data.

5. DISCUSSION AND CONCLUSIONS

Referring to the first research objective the present study finds respondents to be split in their perception of the current environmental status of the Gulf of Gdańsk. There is no agreement as to whether the environmental situation in the Gulf as 'poor' or 'good'. When first confronted with seagrass, protection and restoration do not seem to be a high priority for many respondents. Nonetheless, virtually none of the respondents oppose such measures and 50% of respondents support active protection of seagrass.

As for the second objective, our results indicate significant WTP for changes in the marine environment as a result of a program to restore seagrass. Positive WTP for a reduction of filamentous algae in the water and on the beach is in line with numerous studies that find WTP for improved beach quality and debris management (e.g. Hynes et al., 2013 and Loomis and Santiago, 2013). WTP for algae reduction, however, is not linearly increasing with the amount of algae reduced. According to the mixed logit model respondents are willing to pay €14.48 to ensure algae removal from the beach but not significantly more for their removal from the waters in the Gulf as a whole. This study also finds positive WTP for improved water clarity, a result also found by Taylor and Longo (2010) for the Bulgarian Black Sea coast. When comparing WTP across attributes, it is striking that the attribute with the clearest use characteristic, access to seagrass for boaters and divers, yields the highest WTP (in absolute terms). The aspect of accessibility of the seagrass meadows matters most to respondents, which is remarkable as just 34% (11.4%) of respondents indicated to be sometimes or often active in the water (on the water). Therefore, motivations for this (negative) WTP and the welfare loss it indicates seem to be largely non-use or altruistic or showing dis-appreciation for any kind of restrictions. Additional models were computed to test if WTP for access was particularly high for active marine users, but no significant interaction effects of this attribute with high frequency of activities in (IN_SEA) and on the water (ON_SEA) could be found. However, the difference in the absolute amounts of WTP for NO_ACCESS relative to the other attributes is not large. The reduction of filamentous algae in the water and on the beach and water clarity are also closely linked to the direct use of the Gulf and the adjacent beaches.

With respect to the third objective, this study finds a number of demographic characteristics that influence WTP. Support for the seagrass restoration program is lowest for middle-aged respondents and decreases with household size. Higher household income and more children explain stronger support for the program. Amongst the attitudinal variables, respondents who perceive the environmental situation in the Gulf of Gdańsk as 'good' or 'very good', in particular, are less likely to support the seagrass program. These respondents do not perceive such a strong need for environmental management as it is likely that they base their choices on their own perception rather than the description in the survey material (Kataria et al., 2012). In addition, seagrass meadows are a relatively unknown habitat for the population of the Baltic Sea region (Boström et al., 2014), including the Gulf of Gdańsk. Not surprisingly, therefore, the focus group participants knew little about seagrass meadows and often confused seagrass with reeds and less often with algae. The use of photos, however, allowed survey respondents to link the name of the plant with their previous experience. Respondents without any previous experience were able to use their knowledge about terrestrial grass to imagine the underwater habitat.

The restoration benefits valued in this study can be linked to certain ecosystem service categories which provide a framework for the systematic classification of all channels through which a particular ecosystem supports human well-being. Multiple classifications of ecosystem services and their resulting benefits have been produced (e.g. MEA 2005, TEEB 2010, UK NEA 2011, Böhnke-Henrichs et al., 2013 and Hattam et al., 2015). In the case of the present study, reducing the amount of algae in the water is a form of biological control, enhancement of water clarity refers to water purification and access to seagrass constitutes opportunities for recreation. Linking the environmental consequences described in the individual attributes to ecosystem service categories allows for the valuation estimates of the resulting benefits to be used in value transfer (Richardson et al., 2015) and environmental management in general (Daily et al., 2009).

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