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Economic Valuation of Ecosystem Service Benefits and Welfare Impacts of Offshore Marine Protected Areas: A Study from the Baltic Sea

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Abstract: Knowledge of ecosystem services (ES) and the benefits provided by offshore marine areas, including the welfare impacts from the establishment of marine protected areas (MPAs) is still limited. In the present study we evaluated benefits from ES, citizens' willingness-to-pay for potential changes in the provision of ES, and welfare losses to citizens due to restrictions on economic activities from establishing new offshore MPAs in Latvian waters. The scenarios for the economic valuation were based on analysing the supply of ES from the protected marine habitats, showing changes in the ES supply in policy relevant scenarios of the MPA size. Our study evaluates a wide array of ES delivered by offshore protected habitats and reveals that citizens' willingness-to-pay for preserving habitats and ES supply exceeds their welfare losses from restrictions in economic activities. Our approach supports the prioritisation of habitat types according to their contribution to ES supply and benefits for citizens. The analysis can be complemented with spatial data regarding distribution of habitats, providing an opportunity to identify areas with the highest ES benefits to support marine protection and spatial planning.

Keywords: ecosystem services; offshore marine protected areas; environmental valuation; choice experiment; Baltic Sea; maritime spatial planning

1. Introduction

It is commonly recognized that effectively managed marine protected areas (MPAs) are an important tool to conserve critical habitats, ecosystem services (ES), and the biodiversity that support human life [1]. The current targets for MPAs are based on Aichi target 11 of the Convention on Biological Diversity (CBD), which requires that by 2020 10% of coastal and marine areas, especially areas of particular importance for biodiversity and ES, are conserved through systems of protected areas and other effective area-based conservation measures. At the same time, the results of the literature review by O'Leary et al. (2016) [2] highlight that the 10% target is insufficient to protect marine species. Klein et al. (2015) [3] also found that almost all species with very poor current protection by MPAs are found within exclusive economic zones (EEZ).

Increasing the target set by the CBD is discussed globally, recommending (by 2030) to cover at least 30% of each marine habitat by MPAs [4], or 30% of total marine areas [1].

The 30% target of the marine areas has been agreed recently for the European Union (EU) as part of the new EU Biodiversity Strategy 2030 [5].

The failure of people to fully recognize, and account for, the range of ES benefits provided by the ecosystems is among the key factors of the loss and degradation of those ecosystems [6–8]. Understanding the values of biodiversity and ES and embedding these values in decision-making is essential for ensuring sustainable biodiversity conservation policies [9,10].

MPAs have been the central tool in the practice of marine conservation to protect and restore ecosystems from impacts of human activities [11]. Whether MPAs bring positive ecological impacts depends on many factors, including their management effectiveness [12–14]. There is considerable evidence that ecologically effective and well-managed MPAs provide positive impacts in terms of benefits from preserved biodiversity and ES [14]. At the same time, the establishment of MPAs is often controversial, since excluding human activities from sea areas can have associated negative impacts on those sectors of economy, or groups of society affected by the exclusion [15]. Consequently, the design of MPAs is better addressed from an interdisciplinary perspective that is able to provide insights into the range of potential consequences of implementation [15].

Various economic valuation methods are available to assess the benefits from ES and the socioeconomic impacts of establishing MPAs. As suggested by Glen et al. (2010) [16], the multi-attribute approach of a discrete choice experiment (DCE) method [17,18], which allows eliciting monetary values for non-marketed goods, can facilitate a more in-depth analysis of protected areas than other types of non-market valuation methods (i.e., contingent valuation). The advantage of the DCE method is that the hypothetically marketed good is divided into attributes, which improves its usefulness in a management context [19].

The body of literature using the DCE to determine the economic preferences and value that society attaches to the conservation of the marine environment through MPAs is rapidly growing [15,20]. There is also a growing number of studies on the offshore and deep-sea MPAs, most of them applying the DCE [16,19,21–26]. However, studies that explicitly provide values in terms of benefits from ES in the MPAs are still limited (see Christie et al. (2015) [27] as an example), and very few such studies can be found on the offshore MPAs. Moreover, the studies on the offshore MPAs tend to cover limited ES and values, e.g., option use and non-use values only, like in Jobstvogt et al. (2014) [19]; Wattage et al. (2011) [26], or non-use value only, as in Börger et al. (2014) [23]. With respect to the Baltic Sea, Sagebiel et al. (2016) [28], reviewing empirical valuation studies on the marine ES from 1995 to 2015, concluded that none of the studies has valued more than three ES at once, and around 90% of the studies have valued one ES only. Moreover, there are no studies for the Baltic Sea, valuing the ES benefits for the offshore MPAs.

This paper contributes to the literature eliciting values for the ES provided by marine habitats and assessing welfare impacts to citizens from protecting these habitats by establishment of new offshore MPAs. Our study values a wide array of ES (14 ES), covering a full set of the ES known to date that are delivered by the offshore protected habitats. We analysed the supply of ES from the protected habitats to formulate scenarios for the DCE, showing the changes in the ES supply from different protection extents of various habitat types. We assessed the importance of benefits of individual ES to citizens and valued in monetary terms the changes in the ES benefits and the welfare losses to citizens due to restrictions on economic activities for policy relevant scenarios of new offshore MPAs. This work is the first such empirical study on the offshore MPAs for the Baltic Sea. There is novelty also in the used approach, linking specific habitats to the supply of ES and valuing the benefits of changes in their supplied ES in various scenarios, differing in the size of the MPAs.

2. Environmental and Policy Context of the Study

2.1. Study Area

The study area is located in the Latvian marine waters, belonging to the Baltic Proper Sea basin (Figure 1). 7 MPAs have been established overall [29], covering 15% of the whole Latvian marine waters, and three of them are located in the study area (Figure 1). They are designated primarily with the aim to protect bird populations and are almost exclusively located in territorial waters. At the same time, the EU Habitat Directive's (92/43/EEC) listed reefs are found in the Latvian territorial waters and the EEZ (starting from 20 km off the coast), and they require special protection by establishment of conservation areas. These reefs are areas of hard substrate (rocks or hard minerals), often extensively covered with a variety of mussels and rich in algae, which also makes them a habitat to a range of crustaceans and fish. According to the HELCOM classification [30], 15 types of the reef (benthic hard bottom) habitats are distinguished in the Latvian marine waters (see Appendix Table A1 for full specification of the habitat types). Four of these types relate to the macroalgal communities (called macroalgae habitats), four relate to the mussel communities (mussel habitats), and seven relate to other communities.

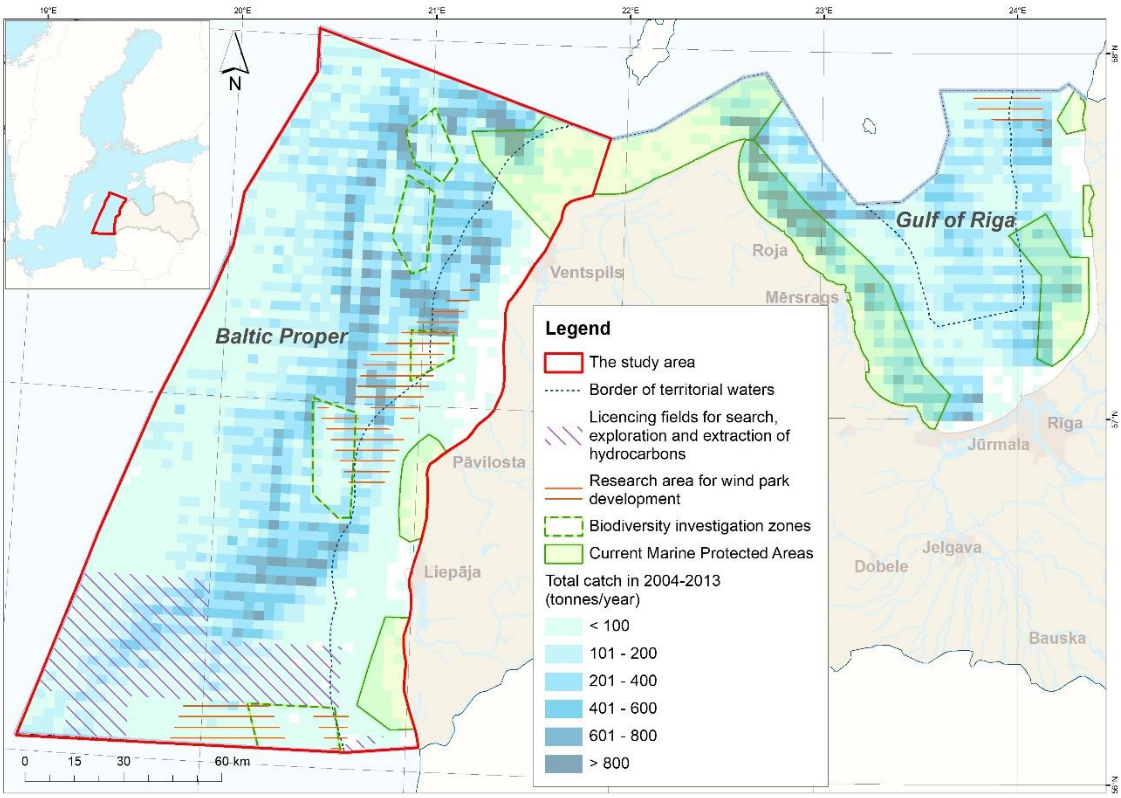

Figure 1. The study area, i.e., the Latvian marine waters in the Baltic Proper basin of the Baltic Sea.

2.2. Policy Context

It has been estimated by the national sea monitoring institution (Latvian Institute of Aquatic Ecology) that the reef habitats could occupy around 3500 km^2 of the study area (with the total area being around 20,500 km^2), and that 24% of this reef area (around 860 km^2) is protected under the current three MPAs. This share is lower than the proposal of the conservation organizations to cover by MPAs up to 30% of each marine habitat [4]. Moreover, it is acknowledged that the actual area of the reef habitats could be larger due to incomplete data for the EEZ waters. Hence, the coverage of the reef habitats under the current MPAs is even lower than the given 24% in the study area.

At the same time, national assessments on the expected future development of the sea use [31,32] indicate that new economic activities could be expected in the study area, in particular, in the EEZ waters, such as offshore wind farms, marine fish farms and oil exploration and extraction. They may have negative impact on the reef habitats, for example, by physical disturbance of the habitats, decreasing their area. For instance, the national "Maritime Spatial Plan 2030" (MSP 2030) [32] sets among the priority sea uses four "investigation zones for potential wind farms" and five "biodiversity investigation zones" for exploring the need for new offshore MPAs (see Figure 1), and these zones partly overlap.

Fisheries is the main current economic activity in the EEZ waters within the study area. Figure 1 provides spatial data on the commercial fisheries' total catch, accounting for all relevant fish species (herring, sprat, cod and flounder) based on data from the national MSP 2030 (the data are available online at https://geolatvija.lv/geo/ [33], accessed on 14.06.2021). It should be noted that bottom trawling, which can negatively impact the reef habitats, is commonly not taking place on the reef habitat areas to avoid damaging nets [34]. Figure 1 also shows potential areas of the new activities in the future, which are indicated based on the national MSP 2030.

New MPAs could be established to preserve the habitat areas from degradation due to the expected development of new economic activities. Due to the focus of the study on the MPAs, which are primarily seen as a spatial protection instrument, we considered only the activities and pressures that impact the habitats and can be managed locally (e.g., physical pressures). There are also other, large-sale pressures that degrade the reef habitats, such as nutrient pollution from land-based activities and impact of invasive species introduced by shipping and other human activities [34], and such future threats as sea-level rise, increasing storm surges, changes in water salinity and temperature due to global climate change [35,36], and unforeseen cumulative impacts [37]. However, other policy instruments are needed to address them. In order to elicit the impact of the MPAs, we considered in our analysis only the local activities and their pressures, while assuming other (the large-scale) pressures on the habitats and factors impacting their state remaining constant in the future.

The environmental impacts of offshore wind farms, marine fish farms, and oil exploration and extraction are locally variable, and there is still limited knowledge about their long term, cumulative impacts on reef habitats in the Baltic Sea. The evidence suggests that, in most cases, construction, operation, and decommissioning of the installations will result in sea-floor disturbance, increased levels of sound and creation of artificial habitats, all of which may have positive and negative impacts on the ecosystem [38,39].

The introduction of hard substrate to the seabed can change the structure of soft substrate habitats [40,41], creating additional space for species that occupy the natural reefs. However, this is unlikely to result in significant change in the composition of reefs [39]. The presence of installations may create fisheries exclusion zone, thus protecting the ecosystem within the buffer zone [42,43]. However, siltation caused by the construction and decommissioning works may negatively affect spawning grounds, cover benthic habitats, and smother benthic species in proximity [44].

Removal of the installations at the end of their life is likely to cause physical disturbances similar to those at construction. At the same time, recent studies show that installations can provide refuge for species on the seabed and water column, supporting abundance and connectivity of sessile invertebrates such as mussels [42,45–47]. Therefore, it may be favourable to leave fractions of the installation in situ as artificial reefs. However, the abandonment as an option for decommissioning needs to be well thought through, as the collapse of abandoned installations may lead to disturbance of the settled drill cutting piles, spreading them further afield [48].

Open fish aquaculture creates nutrient loss through excess feed and fish waste that increases local nutrient concentrations, decreasing water transparency, which is necessary, for instance, for macroalgae to grow. It can also unintentionally introduce and contribute towards the spread of non-native species, alter food webs and biochemical cycles, as well as biodiversity [49].

There is political will to investigate the possibility for establishment of new MPAs in the EEZ waters, so as to increase protection of the offshore reef habitats, preventing their degradation [32,50]. To support this policy process, an economic valuation study, using the DCE method, was carried out. Details on how the new MPAs will be implemented in the future, or to what extent, did not exist at the time of study implementation. Therefore, the study valued various alternative scenarios of protection of the offshore reef habitats, which provide different ES supply levels and resulting welfare impacts.

2.3. Contribution of the Reef Habitats to the ES Supply

The linkages between the reef habitats and ES supply have been analysed for the Latvian marine waters in a study by Armoskaite et al. (2020) [51], which developed an ES assessment tool for the marine ecosystem. The tool specifies the ES supplied by the marine habitats and species and enables quantification of a relative contribution of the habitats in the supply of ES [51,52]. Structure of the tool follows the ES cascade framework [53], by linking the marine ecosystem components (habitats and species) to ecosystem functions and ES. The relative contribution of habitats to the provision of the functions and ES is quantified in the tool in percentages based on expert judgment (see Armoskaite et al. (2020) [51] for more details). Although the tool relies on expert knowledge, it allows capturing the complex ecological linkages between the ecosystem components and the ES supply. The study concludes also that the tool can be used to assess the impacts of environmental changes on the ES supply [51].

The list of ES included in the tool is based on the Common International Classification of Ecosystem Services (CICES, version 5.1) [54], which was adapted to the Latvian marine waters [51]. Some of the ES in the CICES were divided further in the tool for transparency, since different ecosystem components contribute to their supply (see R1 Nutrient regulation and P2 Wild fish for nutrition (human consumption) in Figure 2).

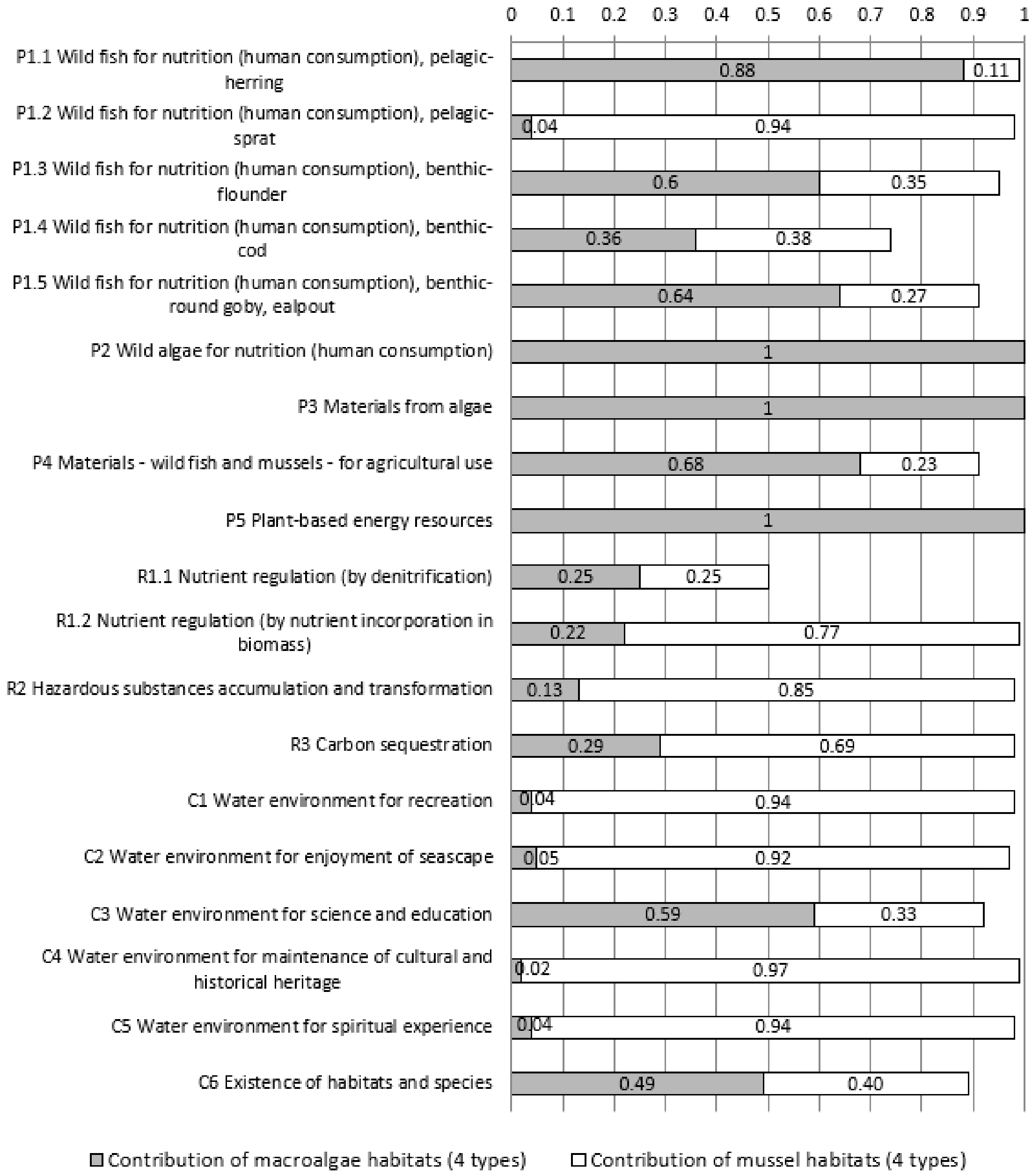

Figure 2. Relative contribution of the macroalgae and mussel habitats to the supply of the ecosystem services (ES) provided by the reef habitats. Note: Total contribution of all reef habitat types (15 types) to the supply of each ES equals to 1 (100%). The gap between 1 and the total contribution of the macroalgae and mussel habitats shows contribution of the other reef habitat types. The estimates are derived from the ES assessment tool described in Armoskaite et al. (2020) [51].

The above-mentioned study shows that the ES are co-produced by various marine habitats – the reef habitats, soft bottom and pelagic habitats, but the reef habitats and associated habitat forming species found within the Latvian waters play a key role and, in some cases, are solely responsible for the supply of ES [51]. Estimates on the relative contribution of the reef habitats to the supply of individual ES are provided in Appendix Table A2. With respect to the various reef habitat types, the largest relative contribution is provided by the habitat types with perennial and annual macroalgal and mussel communities. Figure 2 shows the list of ES provided by the reef habitats (14 ES in total). and the relative contribution of the macroalgae and mussel habitats to their supply, which is calculated by applying the tool.

3. Materials and Methods

3.1. Designing the Discrete Choice Experiment

Assessing the benefits associated with changes in the supply of ES requires understanding of the complex ecological linkages between the ecosystem components and ES supply and performing a valuation study to examine how much people value the changes in the ES supply [27]. We first describe our analysis to assess the changes in the ES supply for various protection extents of the habitats. Based on this analysis, we formulated the scenarios, which were then used for designing the DCE.

3.1.1. ES Supply Scenarios for the Economic Valuation

We employed the ES assessment tool to estimate changes in the ES supply, depending on the protection extent of various reef habitat types (Table 1). It is assumed that outside the MPAs any activity, including such that would result in complete degradation of the habitats, would be allowed. The protection extent can range from 0%, when no protection status is ensured and the habitat area is completely lost, to 100%, when the whole habitat area is highly protected and, hence, preserved. The supply is characterised as the ES ratio, where 1 shows the maximum possible ES supply by the reef habitats, and it is calculated as the mean ratio for all ES. It should be noted that the ratios for individual ES differ significantly from the mean due to differences in the macroalgae and mussel habitats' contribution to the various ES (see Figure 2). Results by the individual ES are provided in Appendix Tables A3 and A4.

Table 1. Supply of the ES (ratio), depending on the protection extent of various reef habitat types.

Estimates with Decreasing Area for Various Reef Habitat Types	**Preserved Habitat Area by Establishing Marine Protected Areas (MPAs) as a Share (%) of the Total Habitat Area**										
	100%	**90%**	**80%**	**70%**	**60%**	**50%**	**40%**	**30%**	**20%**	**10%**	**0%**
(1) with decreasing area of macroalgae habitats only, 100% area for the other reef habitat types	1.00 (1.00)	0.96 (0.93)	0.91 (0.86)	**0.87** **(0.79)**	**0.82** **(0.73)**	0.78 (0.66)	**0.74** **(0.59)**	**0.69** **(0.52)**	0.65 (0.45)	**0.61** **(0.38)**	**0.56** **(0.32)**
(2) with decreasing area of mussel habitats only, 100% area for the other reef habitat types	1.00 (1.00)	0.95 (0.93)	0.90 (0.87)	**0.85** **(0.80)**	**0.80** **(0.73)**	0.75 (0.66)	**0.71** **(0.60)**	**0.66** **(0.53)**	0.61 (0.46)	**0.56** **(0.40)**	**0.51** **(0.33)**
(3) with equal decrease in areas of all reef habitat types	1.00	0.90	0.80	**0.70**	**0.60**	0.50	**0.40**	**0.30**	0.20	**0.10**	**0.00**

Notes: The protection extent characterises the share of the habitat area that is highly protected and, hence, preserved (concerning the macroalgae habitats, the mussel habitats or all the reef habitat types in the estimates (1), (2), and (3) respectively). The ES ratio (in cells) is calculated as the mean ratio for all ES provided by the reef habitats (14 ES), but the ratios in parentheses show the mean ratios for the ES where the contribution of macroalgae (estimate 1), or the mussel (estimate 2) habitats is larger than 25% (see Figure 2). The estimates in bold depict scenarios that formed the basis for the economic valuation (explained later in Section 3.1.1).

Our ES supply analysis indicated that the discussed policy target of protecting 30% of the reef habitat area (based on WPC (2014) [4]) could result in rather low ES supply level (e.g., the mean ratio is 0.3 for the 30% protection extent in estimate 3 in Table 1, which would be the hypothetical worst-case scenario). Therefore, we developed alternative scenarios for the economic valuation, which would allow assessing the benefits of increasing the current protection of the reef habitats (below 24%, i.e., a reference scenario) up to 30% (a moderate policy scenario), as well as the benefits of larger protection extent above this target (a maximum policy scenario).

Since the new MPAs could be established in the EEZ waters, the developed scenarios characterise the ES provision for the EEZ waters, resulting from different protection extents of the offshore reef habitats. The **reference (status quo) scenario** assumes that no new MPAs are established and new activities would cause damage to the reef habitats and a decline in their area and the ES supply. Depending on the new activities, which impact differently various habitat types, and the timeframe (the longer the timeframe, the larger intensity of the new activities can be expected), the ES supply by these habitats could decline down to 0 level, if they are completely lost. However, in the timeframe used for the economic valuation (till 2030), less severe decline can be expected according to the national assessments on future development of the sea use [31,32]. Therefore, an ES ratio in the range of 0–0.6 could be assumed to characterise this scenario (see the range of ES ratios highlighted with bold in Table 1, where the preserved area for various habitat types would be in the range of 0–10% as a minimum). Such ES supply level was labelled for the economic valuation as "poor state of the ES" provided by these habitats.

In the policy scenarios, new offshore MPAs would be established, placing restrictions on economic activities and ensuring certain protection extent of the offshore macroalgae and mussel habitats, which occupy around 99% of the whole reef habitat area in the EEZ waters. The **moderate policy scenario** assumes protecting 30% of the area of each of those habitats, hence, the areas of various habitat types could decline down to 30% in the worst case. An ES ratio in the range of 0.3–0.75 could be assumed to characterise this scenario (see the range of ES ratios highlighted with bold in Table 1, where the preserved area for various habitat types would be in the range of 30–40% as a minimum). Such ES supply level was labelled as "rather good state of the ES". The **maximum policy scenario** assumes protecting 60% of the offshore macroalgae and 60% of the mussel habitats, hence, as a minimum, 60% of their area would be preserved. An ES ratio in the range of 0.6–0.9 could be assumed to characterise this scenario (see the range of ES ratios highlighted with bold in Table 1, where the preserved area for various habitat types would be in the range of 60–70% as a minimum). Such ES supply level was labelled as "very good state of the ES" provided by these habitats.

According to the data on the area of the reef habitats in the study area (with incomplete data for the EEZ waters), the new MPAs covering 30% of the offshore macroalgae and 30% of the mussel habitats (the moderate scenario), together with the current MPAs, would cover slightly above 30% of the total reef area. The size of new MPAs in the maximum scenario would increase the coverage above the discussed 30% target to around 50% of the total reef area.

In line with the target years of relevant EU and the Baltic Sea policies, which include commitments with respect to the MPAs, the year 2030 for the EU Biodiversity strategy [5] and the updated HELCOM Baltic Sea Action Plan, and the year 2027 for the updated program of measures of the EU Marine Strategy Framework Directive (2008/56/EC), the establishment of new MPAs could be expected by 2030. Although acknowledging that the impacts of MPAs will continue also after their establishment, we used a fixed period up to 2030 in our scenarios as a policy relevant timeframe.

3.1.2. Development of the Choice Attributes and Their Levels

The DCE is a survey-based methodology which elicits the willingness-to-pay (WTP) of respondents for a hypothetical non-marketed good. Respondents are asked to choose their preferred option from a set of hypothetical alternatives, which are characterised by attributes that take different levels across the alternatives. The attributes were developed to cover positive and negative welfare impacts on citizens from the establishment of new MPAs in the EEZ waters, which for the survey were referred to as the Latvian "deep-sea waters". The positive impacts from preserving the offshore reef habitats were assessed based on their provided ES. Development of the attributes required specifying the list of relevant ES and their provision in the valued scenarios (based on the analysis presented in Section 3.1.1). The negative impacts relate to the citizens' welfare losses from foregone income and employment in economic activities due to restrictions placed on the activities in the MPAs. Hence, it was necessary to identify relevant activities impacted by the establishment of MPAs and to develop attribute levels characterising these impacts.

The list of ES provided by the reef habitats was taken from the earlier study by Armoskaite et al. (2020) [51] (see also Figure 2). Relevance of these ES for inclusion in the valuation was examined by assessing the importance of benefits derived from these ES for the Latvian population. The benefits were identified based on review of international literature (see for instance, Von Thenen et al. (2020) [55]) and results of previous assessments in Latvia in relation to the marine ES (for example, Ahtiainen et al. (2019) [56]; AKTiiVS (2018) [31]). The list of ES and related benefits was discussed in two focus group discussions with citizens (see Section 3.2, describing the data collection approach for the economic valuation study). As a result, 4 ES were grouped (P2, P3, P4, P5) due to their limited current use (importance) in Latvia. Also, the list and specifications of relevant benefits were refined (the list of benefits is provided in Appendix Table A5). They were further pre-tested in a pilot survey, which included also questions on assessing the importance of the individual benefits (see Section 3.2. for a description of structure of the survey questionnaire). As a result, the list of ES used for the valuation includes the ES that: (i) are understandable and meaningful for people (individuals see the link with their welfare in terms of benefits); (ii) form a comprehensive list, covering the full range of benefits to people from the ES provided by the reef habitats; and (iii) provide distinct and not overlapping benefits to avoid double counting.

With the aim to include the full set of 14 ES in the valuation and to avoid having a high number of attributes in the DCE, the ES were grouped into bundles. Since the macroalgae and mussel habitats make the major contribution to all ES, as well as to facilitate the assessment of the benefits of protecting various reef habitat types, the ES were grouped by these two habitats, grouping under each those ES where they provide significant contribution (see the ES with more than 25% contribution in Figure 2). The only exception is R3 Carbon sequestration (where the estimated contribution is 29% by macroalgae, 69% by mussel and 2% by other reef habitat types, see Figure 2), which was grouped under the macroalgae habitats, since the macroalgae capture CO_2 from the atmosphere, forming the first stage of the carbon cycling in the ecosystem.

The ES grouped under each of the two habitats, which were named in the survey as "macroalgae groves" and "mussel population", formed two environmental attributes for the choice experiment (Figure 3). These ES were explained to survey participants in the first part of the survey, when they were asked to assess the importance of benefits of the individual ES. The ES were referenced also in the choice cards. Consequently, the respondents had detailed information about each included ES.

Under the attribute for macroalgae habitats:	Under the attribute for mussel habitats:
P1 [FISH]	P1 [FISH]
P2, P3, P4, P5 [MATERIALS]	R1, C1, C2, C4, C5 [WATER]
R3 [AIR]	R2 [POLLUTION]
C3 [KNOWLEDGE]	C3 [KNOWLEDGE]
C6 [PRESERVATION]	C6 [PRESERVATION]

Figure 3. Grouping of the ES for the environmental attributes in the choice experiment. Notes: ES codes are explained in Figure 2. The texts in brackets [] provide short names of the ES, which were used in the choice cards.

The attribute levels were specified according to the scenarios described in Section 3.1.1. They included the quantitative protection extent of the habitats according to each scenario (0%, 30% and 60% respectively). The ES supply analysis (the ranges of the ES ratio for each scenario as indicated in Table 1) was used for specifying the state of ES as a *poor*, *rather good*, and *very good* according to each scenario, complementing these specifications with a qualitative description of the state of included ES. A full description of each environmental attribute as used in the final survey is provided in Appendix Figures A2 and A3.

Relevant economic activities, which could be impacted by the new offshore MPAs, were identified based on the national data on the current use of the sea [31,34] and the national MSP 2030 [32], as well as the analysis of potential spatial overlaps and environmental impacts of the activities. Survey participants were informed about current and future economic activities, their potential environmental impacts on the reef habitats, the necessary restrictions on the activities, and how these restrictions could impact the activities (see Appendix Figure A4 for a description of this attribute as used in the final survey).

Diverging from some previous DCE studies on MPAs, where the attribute focused on describing the restrictions (e.g., Glenn et al. (2010) [10]; McVittie and Moran (2010) [24]), we formulated the attribute as "negative impact on economic activities in the deep-sea". For instance, a similar attribute is formulated in Glenn et al. (2010) [10] as "Fishing activity allowed in MPA" with three levels: allow all fishing, ban trawling (but allow other fishing methods), and ban all fishing. McVittie and Moran (2010) [24] include an attribute "Resource extraction and development" with three levels: current restrictions, moderate restrictions, and highly restricted. Our focus groups revealed that people take the restrictions as a necessary precondition to achieve improvement in the ES state (the environmental attributes) and, hence, assign positive value to the restrictions instead of valuing the welfare losses. Therefore, we used a formulation that allows measuring explicitly the welfare losses due to the restrictions. It was explained to respondents that the restrictions relate to requirements for special, environmentally friendly technologies that increase the operation costs, or even banning of the activities, and they may result in foregone income and employment.

The focus groups indicated and the pilot survey confirmed different values attached to the existing activities (fisheries) and the new future activities (off-shore wind farms, marine fish farms and oil exploration and extraction), while all the new activities were seen of similar importance. Hence, we set the levels for this attribute separating fisheries and new activities in order to elicit the difference in the welfare effects if the MPAs affect fisheries or new activities.

Due to the limited analysis of the future sea use and potential spatial conflicts, it was not possible to describe an extent of the impact on the activities in the various new MPA size scenarios. The attribute levels are specified qualitatively, describing whether there is the impact on the various activities. Such qualitative formulations, not including the extent of the impact, can be found also in other DCE studies related to the offshore MPAs (e.g., Aanesen et al. (2015) [21]; Glenn et al. (2010) [10]; McVittie and Moran (2010) [24]). Our aim was to investigate whether there are societal costs from the citizens' perspective if restrictions are placed on various activities due to the establishment of the MPAs.

Survey participants were told that establishing new MPAs requires financing, and that the decided policy option would be financed by collecting money from all adult Latvian inhabitants via a special "Baltic Sea payment", which would be collected in the period from 2020 till 2030 (the timeframe of the scenarios). Previous studies in Latvia have revealed that people have strong opposition against increasing or introducing new taxes [57], hence such special payment for the price attribute was seen more appropriate in order to minimise protest responses. We used a fixed time period for the payment similar to many other offshore MPA studies (for instance, Börger et al. (2014) [23]; Wallmo and Kosaka (2017) [25]), using the year 2030 as the end year to have the same timeframe as for the environmental scenarios.

The price attribute had 9 possible levels: 0, 0.5, 1, 2, 3, 5, 10, 20, 35, and 50 EUR per person annually. The scale was set initially using knowledge from previous stated preference valuation studies for the marine environment in Latvia [57,58], and it was pre-tested in the pilot survey.

The DCE design included 24 choice tasks (Appendix Figure A5 provides an example of the choice task), and they were divided into four blocks, i.e., six choice tasks were presented to each respondent. The experimental design for the final survey was a D-efficient design, optimized for a multinomial logit model (see e.g., Rose and Bliemer (2009) [59]), and the priors for the final design were derived from the pilot survey data.

3.2. Data Collection Approach

The data were collected based on a questionnaire, consisting of five parts. The first two parts included questions related to respondents' visits to and use of the sea, as well as importance of benefits from interaction with the sea (the cultural ES). The third part provided information about the macroalgae and mussel groves in the Latvian marine waters, their provided ES and the benefits to humans, and included questions on previous knowledge about these habitats and on importance of the benefits from the ES. Two types of questions on the importance of benefits were used. Firstly, respondents were asked to assess the importance of each benefit from ES separately on a 10-point scale, where 1 means that the benefit is totally unimportant, 5 that the benefit is of moderate importance and 10 that the benefit is very important (an example of the question is provided in Appendix Figure A1 and the used list of ES and related benefits is provided in Appendix Table A5). This question aimed to familiarize respondents with the ES provided by the habitats and the related benefits to humans, as well as to facilitate thinking about personal importance of these benefits. Secondly, respondents were asked to consider all the benefits together and to assess relative importance of each benefit by allocating 100 points among the listed benefits. This question provides comparative assessment of the importance of the full set of benefits.

In the fourth part of the questionnaire respondents were provided information about the future threats to the habitats in the offshore waters due to the potential new economic activities, as well as the MPAs as an instrument for preserving the habitats. They were informed that the MPAs as a policy instrument can include restrictions to economic activities, as well as local habitat restoration measures to prevent negative environmental impacts and to improve the state of the habitats. Respondents were presented information about each attribute and their levels in each scenario (Appendix Figures A2–A4) and were provided information related to the choice tasks, including instructions for completing the choice questions. Respondents were reminded to account for their budget when making the choices. After completing the choice tasks, respondents were asked their motivation for being, or not being willing to pay and importance of the attributes when making the choices. The last part of the questionnaire included questions to collect data on socio-demographic characteristics of respondents and their feedback on completing the survey.

The development of the questionnaire and the data collection were based on two focus group discussion with citizens in May 2019, a pilot survey in June-July 2019 and a final survey in October-November 2019. All stages were implemented by a professional survey company (market and public opinion research centre "SKDS").

The focus group discussions were aimed at supporting the development and pretesting of relevant elements of the questionnaire. The discussions involved eight participants each, who were selected to represent the structure of the national population according to gender, age, education level, nationality, and administrative territory (region).

The questionnaire was pretested in the pilot survey with 100 residents of Latvia by carrying out personal interviews at their place of residence. A stratified random sampling approach was used for both the pilot and the final survey, using for the stratification the socio-demographic characteristics listed above, to ensure that the structure of the sample corresponds to the structure of the national residential population (in the age group 18–74). In the final survey, 701 respondents completed the questionnaire. Such sample size (n = 701) is seen as appropriate for a representative national sample, taking into account the size of the Latvian population (1,522,000 inhabitants in the age group 18–74), and has been used also in previous national surveys in Latvia [56,60,61]. Half of the interviews were conducted as computer assisted personal interviews (CAPI) and half as computer assisted web interviews (CAWI) (351 and 350 respectively). The overall response rate (respondents who completed the survey, as a proportion of all respondents who were contacted for the survey) was 18.4% (11.6% for CAWI and 44.4% for CAPI). The average time of completing the survey was 30 min.

3.3. Econometric Analysis of the Choice Data

The statistical analysis of DCE data is based on the random utility framework [62]. According to the framework, the indirect utility function for each respondent includes a deterministic part that is determined by the attributes of the alternatives in the choice experiment and characteristics of the respondent, and a stochastic part that represents unobservable effects on individual choice.

Since it was reasonable to assume that preferences for the characteristics of the Baltic Sea environment vary across the population, we applied the mixed logit (MXL) model that allows for individual preference heterogeneity through random parameters for the attributes and has the advantage of not requiring the independence of irrelevant alternatives (IIA) assumption [63,64] and allowing flexibility in specifying individual, unobserved heterogeneity [65].

The random parameters vary over individuals according to continuous probability functions, picking up unobserved preference heterogeneity across individuals that cannot be explained with explanatory variables. Additionally, to examine whether the respondent's characteristics explain part of the heterogeneity in the preferences, factors describing respondent's characteristics were interacted with the attributes in the model, and the significance of these interaction terms reveals whether the factors affect the preferences for the attributes.

Formally, respondent n's (n = 1, …, N) utility associated with choosing alternative j in the choice task t is represented by the linear utility expression [64]:

$$U_{njt} = \beta_n' X_{njt} + \varepsilon_{njt} \quad (1)$$

$$U_{njt} = (b' + s'\eta_n) X_{njt} + \varepsilon_{njt} \quad (2)$$

where X_{njt} is a vector of attributes of the alternatives, β_n' are the individual-specific coefficients for the attributes, which consist of the mean of the coefficient over the respondents (b') and the randomly distributed individual-specific random term $s'\eta_n$ that represents how the person's preferences differ from the average preferences in the population, where η represents the unobserved heterogeneity in the coefficients, following a specific distribution with location and scale parameters b and s. Term ε_{njt} is a random term that is independent and identically distributed (iid). This specification is the same as for standard multinomial logit model, except that β varies over respondents rather than being fixed.

In the mixed logit model, distributions are specified for the coefficients and then the parameters of these distributions are estimated. Most common distributions are normal and log-normal [64]. The coefficients for the environmental attributes (macroalgae groves, mussel population), impacts on economic activities and the alternative-specific constant for choosing the status quo option (ASCsq) were assigned a normal distribution. To limit the coefficient for the cost attribute to negative values, a log-normal distribution was used for the cost. For each respondent, the coefficients were assumed to be constant over the choice tasks.

In the models, the attributes for macroalgae, mussel population and economic activities were dummy coded to allow for non-linearity in utility, with the lowest level as the reference level. Thus, the coefficients for the attribute levels represent changes in utility compared to the status quo level. The cost variable was specified as continuous. The maximum likelihood was simulated using 1500 Halton draws with 1000 draws discarded as burn-in. The models were estimated using Stata software (Stata 13.1, StataCorp, College Station, TX, USA).

The marginal WTP estimates were calculated as the negative ratio of the parameters for non-monetary attributes and the cost parameter. As the cost is log-normally distributed, the mean estimate for the cost is given by:

$$mean_{cost} = (-1) \times exp\left(\mu + \frac{\sigma^2}{2}\right) \quad (3)$$

where μ is the coefficient of mean and σ the coefficient of the standard deviation, multiplied by −1 as the negative of cost enters the utility function because lognormal distribution is limited to be positive [66]. Confidence intervals were calculated with the Krinsky-Robb procedure [67] using the nlcom command in Stata.

For the analysis of the choice data, 76 respondents (10.8% of the sample) were identified as protesters and were removed from the sample for the choice modelling. Protest responses are not considered to represent "true" values for the environmental good in question, but respondents, who give these responses, rather reject some element of the valuation scenario, for example, oppose the payment vehicle or the credibility of the exercise (see e.g., Meyerhoff and Liebe (2006) [68]). As there are no standard rules for the identification and handling of the protest responses, their treatment is often based on researchers' subjective judgment [69,70]. We identified the protesters based on the responses to a follow-up question on the motivation for not being willing to pay (see Appendix Table A6 for the answer options that are classified as the protest responses). Those, who objected the additional payment in general, who did not believe in achieving a good state of the environmental attributes, or using the money for the stated purpose, were classified as the protesters and removed from the sample for the main model, which is common practice in the stated preference studies [68]. The sample after excluding the protesters is still representative of the general population (the data characterising the representativeness are provided in Appendix Table A7). At the same time, for sensitivity analysis, we present also results of the model and WTP estimates based on the full sample.

4. Results

4.1. Survey Respondents

The data characterising representativeness of the sample of the final survey are provided in Appendix Table A7. When comparing the data on the sample's socio-demographic characteristics against population means, the results show that the mean shares in the sample correspond to the means of the national population for all the main socio-demographic characteristics, including the mean disposable income. Therefore, the survey sample was considered to reflect the Latvian population, and the survey results can be considered to be representative of the views of the national resident population as a whole.

4.2. Importance of Benefits from the Offshore Macroalgae and Mussel Habitats' Provided Ecosystem Services

Table 2 presents the results of the importance of benefits from the individual ES provided by the macroalgae and mussel habitats. These results are based on the data from the whole sample ($n = 701$). Results of both types of the questions (with the 10-point scale and allocating 100 points among the ES) are included. The results show that the highest importance is assigned overall to the benefits from the regulating ES (B3–B5), with the mean scores between 8.3 and 8.9 out of 10 and around 40 points out of 100 allocated to all of these benefits. The benefits related to food from wild sea fish for human consumption (B1) is also assessed with similarly high importance, although this assessment has higher standard deviation, indicating difference in the importance across respondents. Benefits from the cultural ES related to recreation and enjoyment of sea scape (B6, B7) follow as the next important ones. Non-use value of the macroalgae and mussel habitats and related species (B11) is also assessed as being quite important. Benefits from the other cultural ES

(B8–B10), as well as materials from wild sea fish and algae (B2) are seen as the least important ones.

Table 2. Respondents' assessment of importance of the benefits from the offshore macroalgae and mussel habitats' provided ES. Estimated means and standard deviations from the data of a representative national sample (n = 701).

Benefits from the ES Provided by the Offshore Macroalgae and Mussel Habitats [1]	Importance of the Benefits (with Score from 1 to 10)		Relative Importance of the Benefits (Allocating Points out of 100) [2]	
	Mean Score from the Sample	Std. Dev.	Average Points from the Sample	Std. Dev.
B1 Food from wild sea fish for human consumption	8.11	2.12	23.63	16.29
B2 Materials from wild sea fish and macroalgae for various human needs	6.67	2.50	9.35	6.96
B3 Quality of the water environment by assimilation of nutrient excess from human activities	8.30	1.93	12.23	6.89
B4 From hazardous polluting substances clean water environment for humans and marine animals	8.72	1.60	16.01	9.37
B5 Improving atmospheric conditions by carbon capture and storage reducing carbon dioxide and other greenhouse gasses in the atmosphere	8.87	1.46	14.57	7.74
B6 Feelings from leisure activities at the sea (supported by quality of the water environment)	8.57	1.67	10.97 (together for B6 and B7)	7.42 (together for B6 and B7)
B7 Feelings from enjoyment of the sea scape (supported by quality of the water environment)	8.42	1.73		
B8 Opportunities for visiting historical and cultural places, maintenance of the sea related traditions and culture (supported by quality of the water environment)	6.78	2.38	5.32 (together for B8-B10)	5.03 (together for B8-B10)
B9 Spiritual emotions and symbols, which create sense of place/belonging and identity, spiritual experience (supported by quality of the water environment)	6.57	2.57		
B10 Education and obtaining new information (supported by quality of the water environment)	6.55	2.39		
B11 Moral satisfaction from and/or responsibility for existence and preservation for future generations of the marine habitats and related species [3]	7.77	2.17	7.90	7.32

Notes: [1] Respondents were provided detailed description of each ES and related benefit. More succinct formulations of the benefits are used here. [2] Due to specific format of the question, some benefits were grouped to reduce the number of items for the assessment (e.g., B6 and B7; B8–B10). [3] This benefit covers non-use value of the assessed benthic habitats and species related to them.

4.3. Choice Experiment Modelling Results

Results of the MXL model applied to the choice data (see Table 3) show that the coefficients of all attributes are statistically significant at 1% level and of the expected sign. The positive coefficients of both environmental attributes indicate increased utility from the valued improvements in the state of the ES. The negative coefficients for the negative impacts on economic activities imply that these impacts reduce respondents' utility. The absolute values of the coefficients for the two economic activities' variables are smaller than for either of the environmental attributes. This implies that citizens attach larger value to the improved state of the ES from offshore macroalgae and mussel habitats than to the negative impacts on economic activities for achieving this state, by establishing the MPAs. The coefficient for cost attribute is negative, meaning that higher costs reduce the probability of choosing the alternative. The statistically significant negative coefficient for the alternative specific constant (ASCsq) variable suggests that individuals tend to favour the policy alternatives over the *status quo* alternative. There is significant preference heterogeneity across individuals for some of the attributes and attribute levels, as indicated by significant standard deviations for the parameters *ASC status quo*, *state of services of mussel habitats: rather good*, *negative impact on the deep-sea fisheries* and *costs* (see Table 3). In particular, the heterogeneity for the *ASC status quo* is considerable, indicating a large variation in the preferences for and against the establishment of new MPAs, regardless of the attribute levels.

Table 3. Results of the mixed logit model (MXL) and marginal willingness-to-pay (WTP) estimates.

Random Parameters	Coefficient (Standard Error)	Significance (Z Value)	Mean WTP, EUR Per Person Per Year [95% Confidence Interval]
ASCsq	−2.892 *** (0.342)	−8.44	−5.70 [−7.73; −3.67]
State of services of macroalgae habitats: rather good	1.373 *** (0.100)	13.67	2.71 [1.77; 3.64]
State of services of macroalgae habitats: very good	1.451 *** (0.108)	13.39	2.86 [1.85; 3.87]
State of services of mussel habitats: rather good	1.483 *** (0.104)	14.22	2.92 [1.91; 3.94]
State of services of mussel habitats: very good	1.510 *** (0.102)	14.74	2.98 [1.93; 4.02]
Negative impact on economic activities in the deep-sea: fisheries	−0.614 *** (0.094)	−6.54	−1.21 [−1.75; −0.68]
Negative impact on economic activities in the deep-sea: new activities	−0.415 *** (0.077)	−5.41	−0.82 [−1.21; −0.42]
Cost	−2.621 *** (0.124)	−21.19	
Standard Deviations for Random Parameters	**Standard Deviation (Standard Error)**	**Significance**	
ASCsq	4.365 *** (0.349)	12.49	
State of services of macroalgae habitats: rather good	0.387 (0.238)	1.63	
State of services of macroalgae habitats: very good	0.033 (0.461)	0.07	
State of services of mussel habitats: rather good	0.615 *** (0.192)	3.2	
State of services of mussel habitats: very good	0.012 (0.239)	0.05	
Negative impact on economic activities in the deep-sea: fisheries	0.752 *** (0.143)	5.24	
Negative impact on economic activities in the deep-sea: new activities	0.026 (0.255)	0.10	
Cost	1.971 *** (0.098)	20.22	
Number of observations	11250		
Number of respondents	625		
Log-likelihood	−2842.3		
Bayesian information criterion	5833.9		
Akaike information criterion	5716.7		

The number of asterisks for coefficients indicates their level of statistical significance (i.e. the coefficients are significant at the 1% (***), 5% (**), or 10% (*) level). The cost is log-normal.

Table 3 presents also the marginal WTP estimates for all attribute levels. Since the variables in the choice model are dummy coded, the WTP estimate for each attribute level represents the welfare impacts of changes from the *status quo* level (*poor* state of the services, no negative impact on the economic activities) to the policy level (*rather good* or *very good* state of the services, *negative impact on fisheries* or *new activities*). Larger improvements in the environmental attributes are associated with higher WTP, but the difference in the

WTP between the *rather good* and *very good* level is rather small, and the confidence intervals overlap. Such decreasing marginal utility, when the WTP does not increase linearly with the environmental improvements, has also been observed in other studies, for example, in Börger et al. (2014) [23] for increased species diversity and protection level of porpoises, seals and seabirds in the offshore MPAs, as well as in other DCE studies for the marine environment in Latvia (e.g., Pakalniete et al. (2017) [57]).

Results also reveal that respondents tend to derive slightly higher utility from improving the state of ES provided by the offshore mussel habitats compared to ES from the macroalgae habitats, but the difference is rather small. Since the 95% confidence intervals for the WTP estimates are largely overlapping, the difference is likely not statistically significant. The negative impacts to fisheries bring slightly larger disutility compared to the negative impacts on new activities.

The MXL model based on the full sample, including protesters, shows similar results in terms of the coefficient signs and significance of the variables, but the marginal WTP estimates are somewhat lower for the environmental attributes (see Appendix Table A9 for the detailed results of this model).

The results of the MXL model with socio-demographic interaction variables (Appendix Table A8) indicate that higher income increases the positive utility from changes in the environmental attributes (the state of services of macroalgae and mussel habitats), but does not affect the utility losses from the negative impacts on economic activities. Older people generally experience lower effects on utility from changes in all the attributes, and males perceive less utility from changes in the environmental attributes. Education does not seem to explain preference heterogeneity when income differences are accounted for.

4.4. Welfare Impacts of the Offshore MPA Scenarios to Citizens

We apply the WTP results to illustrate the welfare impacts on citizens for the two potential MPA scenarios. In the *moderate policy scenario*, it is assumed that the new MPAs leave sufficient space for the new activities outside the MPAs, without increasing their operation costs, and hence without negative impact on the new activities. Since the bottom trawling, which can impact negatively the reef habitats, is commonly not taking place in the reef habitat area, there would be no need for the restrictions on the fishery in the new MPAs. Hence, it would not be impacted directly by the establishment of the new MPAs. However, the claim for space by the new activities outside the MPAs might reduce the offshore area that is available for the fisheries. Therefore, the *moderate policy scenario* would provide a *rather good* state of ES of the offshore macroalgae and mussel habitats and create a negative impact on the fisheries. The mean WTP for such a scenario is 10.1 EUR (6.9–13.4 EUR CI 95%) per person per year, including the ASC. The *maximum policy scenario* would provide a *very good* state of ES of the habitats and, due to the large size of the MPAs, could create negative impact on both the new activities and fisheries. The mean WTP for such scenario is 9.5 EUR (6.4–12.6 EUR CI 95%), including the ASC. When using the mean WTP estimates based on the full sample, including protesters, these estimates decrease somewhat, with WTP being 8.9 EUR (6.5–11.4 EUR CI 95%) per person per year for the *moderate scenario* and 8.4 EUR (6.1–10.7 EUR CI 95%) per person per year for the *maximum policy scenario*.

The results reveal that both policy scenarios would bring relatively similar benefits to citizens, with the benefits from the *moderate scenario* slightly exceeding the benefits from the *maximum scenario*, as the increase in the benefits when moving from *rather good* to *very good* state of the ES is smaller than the increase in welfare losses due to negative impacts on both the fisheries and the new economic activities.

5. Discussion

Our study aimed to value the ES benefits and welfare impacts on citizens from establishing new offshore MPAs. Unlike most previous valuation studies for the offshore MPAs, our study values a wide array of the ES delivered by the offshore reef (benthic hard bottom) habitats. The ES supply analysis confirmed that the individual ES are co-produced by biotic and abiotic features of various habitats, e.g., the reef, benthic soft bottom and pelagic habitats. We focused on the reef habitats due to their special protection status according to the EU Habitat directive (92/43/EEC), but our approach is applicable to other marine habitats also to assess the welfare impacts of their preservation.

While the protection must be ensured for the reef habitats in general, our analysis indicates that the protection of various reef habitat types would result in different supply levels of the individual ES (see Appendix Tables A3 and A4), as well as resulting benefits to citizens. The results of the DCE and the importance of the benefits from the individual ES reveal that the ES provided by the mussel habitats are valued slightly higher overall by the Latvian population than those provided by the macroalgae habitats. It is due to the major contribution of the mussel habitats to the regulating ES, as well as to ensuring the quality of water environment for the recreational ES, which were assessed as more important than the other ES provided by the reef habitats. Macroalgae habitats are the main contributors to most provisioning ES, including by providing materials for energy production and various other human needs. While the benefits from wild fish for human consumption are seen highly important by the Latvian citizens, other provisioning ES are assigned lower importance of the benefits. However, the results suggest that, with respect to the reef habitat types, both the mussel and the macroalgae habitat types should be targeted primarily for designating MPAs due to their contribution to a wide array of relevant ES.

Our WTP estimates for the environmental attributes (the state of ES provided by macroalgae and mussel habitats, without accounting value of the ASC) are overall of similar magnitude as in the previous stated preference valuation studies in Latvia, where they range from 0.5 to 7 EUR per person per year for various marine environmental goods [57,58,60]. More detailed comparison is not possible, since the valued environmental goods differ in the previous studies. No comparable studies exist in the Baltic Sea, since previous stated preference studies have covered a limited number of marine ES [28], while our study provides aggregated estimates for sets of all relevant ES. Moreover, as noted by Sagebiel et al. (2016) [28], the WTP values vary among the riparian states, limiting the comparison. Also coordinated studies, valuing the same marine environmental good in several or all Baltic Sea countries [58,60], confirm this variation, with the differences in WTP across countries being explained primarily by income differences [58,60]. The income level of the Latvian population, and thus also the average WTP, are the lowest among the coastal countries.

With the aim to cover the full set of (14) ES in the valuation, we grouped them for the DCE attributes into bundles of clearly specified ES. We combined an assessment of importance of the individual ES benefits with the DCE results, which allows monetary valuation of changes in these benefits for various policy scenarios. The clear specification of the included ES and related benefits facilitates transparency and transferability of our results. The results can be complemented with monetary assessments of benefits and socio-economic values of the individual ES. Our used approach also facilitates linking such assessments to specific habitat types based on their contribution to the provision of these ES. This kind of analysis can support discussing trade-offs of protecting various habitat types. Combining such results with spatial data about distribution of the habitats provides an opportunity to identify areas with the highest ES benefits to support the marine protection and spatial planning.

We aimed also to value the welfare impacts of various scenarios of new MPA size in terms of the habitat area covered by MPAs. The DCE results reveal decreasing marginal utility from improving the ES; the WTP for the ES state improvement in the *moderate scenario* (*rather good* state of the ES, when preserving 30% of the offshore reef habitats) is almost as high as for the *maximum scenario* (*very good* state of the ES, when preserving 60%). When accounting also the negative impact, the results suggest that citizens are willing to accept the adverse effect on the economic activities, as indicated by the higher WTP for the environmental improvements than for avoiding the negative impact on the activities. From the citizens' perspective, this result justifies the value of increasing the current protection of the reef habitat area by MPAs in the study area (below 24%) up to 30% according to the recommendation of conservation organizations [4]. The net benefits to citizens from further expanding the MPA size could still be positive, with the benefits from improving the ES state outweighing the welfare losses, even if accounting the negative impact on both the fisheries and the new economic activities. Hence, from the perspective of the general public, also larger size of MPAs than the given 30% target could be justified. Although, our results indicate that the *moderate scenario* could be more optimal from the citizens' perspective, since the net benefits from the *moderate scenario* exceed slightly the benefits from the *maximum scenario*. It should be noted however that these results account only the welfare impacts on citizens. The possible impacts of the new MPAs on the sectors of economy (e.g., changes in their operation costs and profits) are not covered by this valuation.

The various values generated by the study (e.g., related to various reef habitat types and their protection extents) build on the used approach, which links explicitly specific marine habitats to the supply of ES and values the benefits of changes in their supplied ES. The integration of environmental science within the valuation of ES is recommended to improve the contribution of valuation to management of marine ecosystems [20]. However, it has been argued to be challenging with respect to the offshore and deep-sea ecosystems due to the lack of scientific knowledge [19–21]. We demonstrate an approach for such integration, and, to our knowledge, there are no such similar valuation studies for the offshore MPAs. However, uncertainties in our results must be recognized. Firstly, they relate to the assessment of the ES supply, depending on the protection extent (area) of various reef habitat types, which was elaborated by applying the ES assessment tool (described in Armoskaite et al. (2020) [51]). The assessment depends on the contribution of specific habitat types to the supply of individual ES. This contribution is assessed in the tool based on expert judgement, which always involves certain degree of uncertainty. In addition, the tool accounts only changes in the habitat area for the resulting ES supply levels, without taking into account other factors that underpin relationships between the habitat area size and the ES production (e.g., quality of the habitats across area units, possible non-linearity in the ES production function).

Secondly, the ES supply level depends on the (actually) preserved habitat area, requiring an assessment on the extent of the habitat area loss outside the MPAs. An assumption that the whole habitat area outside the MPAs is completely lost due to new economic activities depicts the most pessimistic situation and is unrealistic, taking into account the national assessments on expected intensity of the new activities in the medium-term future. The actual changes in the area of the reef habitats would depend on the intensity of the new activities (size of their occupied area), their spatial location and environmental impacts on the reef habitats. Due to the focus of the study on the economic valuation, it was outside of the scope of the study to perform a detailed assessment of the future development of the new offshore economic activities, their impact on various reef habitat types, and the resulting changes in the habitat area. While data for the study area, information from the national policy planning documents, and the literature on potential impacts of the activities formed the background for the analysis, the ES supply scenarios are simulated, by applying the ES assessment tool. Therefore, we used for each scenario of the specified protection extent (0%, 30%, or 60% of the habitat area) a range of the preserved habitat area and an interval of the resulting ES supply level (ES ratio).

Due to all these uncertainties, we used in the DCE a qualitative formulation of the attribute levels on the ES state, resulting from the specified protection extents. It increases further the uncertainty of the result on the benefits linked to the specified protection extents, and, therefore, this result should be interpreted with a certain level of caution. Quantitative specifications of the attribute levels would be preferable to increase the content validity (see, for instance, Johnston et al. (2012) [71]). At the same time, qualitative attribute levels can be found also in previous DCE studies related to the offshore and coastal MPAs [19,21,23,24,72]. More concrete scenarios for the expected changes in the habitat area and the resulting changes in the ES supply would allow formulating the DCE attributes in a more quantitative way, but such scenarios need to be underpinned with detailed and spatially explicit assessments of changes in the sea uses and their impact on the habitats. We conclude that limited environmental information and assessments for the offshore marine areas restricts the possibilities of using quantitative attribute levels. Information from geophysical and sedimentological surveys (see Madricardo et al. 2019 [73]; De Giosa et al. 2019 [74]; Scardino et al. 2020 [75]) and more detailed assessment of the ES supply, using the field data, are relevant for solving these limitations.

6. Conclusions

Our study, valuing the welfare impacts on citizens from offshore MPAs in the Baltic Sea, clearly demonstrates a wide array of ES provided by the offshore habitats and the conservation benefits for the general public. Although unfamiliar with this remote environment, Latvian citizens are willing to pay for protecting the habitats, when provided with information about their contribution to human wellbeing in terms of the ES. Moreover, the results reveal that the Latvian citizens are willing to accept negative impacts on the offshore economic activities to ensure good state of the offshore habitats and supply of the ES. In light of the demand for increasing areas of habitat protected by the MPAs, our results can support the policy discussions on designating new MPAs in the offshore waters. We hope that our value evidence will contribute towards improving the protection of the Baltic Sea biodiversity and the supply of the ES. Understanding the socioeconomic benefits of MPAs can assist also MSP by illustrating that the value of protecting ecologically important marine areas goes beyond that of biodiversity conservation. The analysis can be complemented with spatial data on the distribution of the habitats, providing an opportunity to identify marine areas with the highest ES benefits. Therefore, the described approach can provide a foundation for the economic assessment of MPAs in the MSP process.

We also believe that our approach, which links explicitly specific habitats to the supply of ES and the benefits, resulted in new knowledge and evidence on the welfare impacts of protecting various marine habitats. Results are relevant for other marine areas with presence of similar habitats. Moreover, we tried to link the changes throughout this habitat-ES-benefit chain to specified policy options of the extent of MPAs in terms of the covered habitat area. It has been suggested that results from valuation studies of this kind can be the most informative to marine management if the link between proposed management options, ensuing environmental change, and the assessment of the resulting benefits is as clear and direct as possible [24]. Despite the uncertainties, our approach and results provide useful knowledge on the welfare impacts of different protection extents of various marine habitats to support the marine protection and spatial planning.

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Appendix A

Table A1. The benthic hard bottom (reef) habitats in the Latvian marine waters. Source: Classification of the habitats according to HELCOM (2013) [30]. Data on the habitat areas according to the data of Latvian Institute of Aquatic Ecology. Note: the habitat types related to macroalgae are indicated with green colour, the types related to mussel with yellow and the other reef habitat types with blue colour.

Habitat Name	Habitat Description	Habitat Area in the Study Area—The Latvian Marine Waters in the Baltic Proper (km^2)
Photic and aphotic hard substrate benthic habitats		
AA.A w/perennial algae	Photic hard substrate habitats with dominance of perennial macroalgal communities	33
AA.A w/annual algae	Photic hard substrate habitats with dominance of annual macroalgal communities	5
AA.A w/epibenthic bivalves	Photic hard substrate habitats with dominance of epibenthic bivalve (Mytillus sp.) communities	523
AB.A w/epibenthic bivalves	Aphotic hard substrate habitats with dominance of epibenthic bivalve (Mytillus sp.) communities	1159
AA.A w/epibenthic crustacea	Photic hard substrate habitats with dominance of epibenthic crustacean (Balanus sp.) communities	0
AB.A w/epibenthic crustacea	Aphotic hard substrate habitats with dominance of epibenthic crustacean (Balanus sp.) communities	0
AA.A w/sparse epibenthic macrocommunity	Photic hard substrate habitats with sparse epibenthic macrocommunity	11
Photic and aphotic mixed substrate benthic habitats		
AA.M w/perennial algae	Photic mixed substrate habitats with dominance of perennial macroalgal communities	49
AA.M w/annual algae	Photic mixed substrate habitats with dominance of annual macroalgal communities	3
AA.M w/epibenthic bivalves	Photic mixed substrate habitats with dominance of epibenthic bivalve (Mytillus sp.) communities	361
AB.M w/epibenthic bivalves	Aphotic mixed substrate habitats with dominance of epibenthic bivalve (Mytillus sp.) communities	1239
AA.M w/epibenthic crustacea	Photic mixed substrate habitats with dominance of epibenthic crustacean (Balanus sp.) communities	1

AB.M w/epienthic crustacea	Aphotic mixed substrate habitats with dominance of epibenthic crustacean (Balanus sp.) communities	0
AA.M w/sparse epibenthic macrocommunity	Photic mixed substrate habitats with sparse epibenthic macrocommunity	91
AB.M w/sparse epibenthic macrocommunity	Aphotic mixed substrate habitats with sparse epibenthic macrocommunity	89
TOTAL:		3564

Table A2. Relative contribution of the reef (benthic hard bottom) habitats to the provision of ES. Source: The estimates are derived from the ES assessment tool described in Armoskaite et al. (2020) [51]. Notes: Those ES are included where the reef habitats provide any contribution. The total contribution provided by all marine habitats (benthic hard bottom, soft bottom, pelagic habitats) equals to 100%.

List of Ecosystem Services	Relative Contribution of the Reef Habitats (%)
P1.1 Wild fish for nutrition (human consumption), pelagic-herring	39.8
P1.2 Wild fish for nutrition (human consumption), pelagic-sprat	4.8
P1.3 Wild fish for nutrition (human consumption), benthic-flounder	67.7
P1.4 Wild fish for nutrition (human consumption), benthic-cod	18.5
P1.5 Wild fish for nutrition (human consumption), benthic-round goby, ealpout	76.9
P2 Wild algae for nutrition (human consumption)	100.0
P3 Materials from algae	100.0
P4 Materials—wild fish and mussels—for agricultural use	37.8
P5 Plant-based energy resources	100.0
R1.1 Nutrient regulation (by denitrification)	8.0
R1.2 Nutrient regulation (by nutrient incorporation in biomass)	82.7
R2 Hazardous substances accumulation and transformation	58.6
R3 Carbon sequestration	39.6
C1 Water environment for recreation	52.8
C2 Water environment for enjoyment of seascape	24.8
C3 Water environment for science and education	41.3
C4 Water environment for maintenance of cultural and historical heritage	7.3
C5 Water environment for spiritual experience	28.8
C6 Existence of habitats and species	45.9
Mean relative contribution for all ES	**49.2**

Table A3. Supply of ES (ratio) depending on the protection extent of the macroalgae habitats. Source: The ES ratios are calculated, employing the ES assessment tool described in Armoskaite et al. (2020) [51], based on the reef habitat data for the study area. Notes: The contribution of the reef habitats to the ES supply is accounted as 100%, excluding contribution of other habitats (e.g., soft bottom habitats, pelagic habitats). The protection extent characterises the share of the macroalgae habitat area that is highly protected and, hence, preserved. A constant area for the other reef habitat types at 100% level is assumed. The ES ratio ranges from 0 to 1, where 1 shows the maximum possible ES supply by the reef habitats (e.g., when 100% of the area is preserved). The colours denote the ES ratio: 0–25, 25–50, 50–75, and 75–100.

ES provided by the reef habitats	Preserved macroalgae habitat area by MPAs as a share of their total area										
	100%	**90%**	**80%**	**70%**	**60%**	**50%**	**40%**	**30%**	**20%**	**10%**	**0%**
R1.1 Nutrient regulation (by denitrification)	1.00	0.98	0.95	0.93	0.90	0.88	0.85	0.83	0.80	0.78	0.75
R1.2 Nutrient regulation (by nutrient incorporation in biomass)	1.00	0.98	0.96	0.94	0.91	0.89	0.87	0.85	0.83	0.81	0.78
R2 Hazardous substances accumulation and transformation	1.00	0.99	0.97	0.96	0.95	0.94	0.92	0.91	0.90	0.89	0.87
R3 Carbon sequestration	1.00	0.97	0.94	0.91	0.88	0.86	0.83	0.80	0.77	0.74	0.71

P1 Wild algae for nutrition (human consumption)	1.00	0.90	0.80	0.70	0.60	0.50	0.40	0.30	0.20	0.10	0.00
P2.1 Wild fish for nutrition (human consumption), pelagic-herring	1.00	0.91	0.82	0.73	0.65	0.56	0.47	0.38	0.29	0.20	0.12
P2.2 Wild fish for nutrition (human consumption), pelagic-sprat	1.00	1.00	0.99	0.99	0.98	0.98	0.98	0.97	0.97	0.96	0.96
P2.3 Wild fish for nutrition (human consumption), benthic-flounder	1.00	0.94	0.88	0.82	0.76	0.70	0.64	0.58	0.52	0.46	0.40
P2.4 Wild fish for nutrition (human consumption), benthic- cod	1.00	0.96	0.93	0.89	0.85	0.82	0.78	0.74	0.71	0.67	0.64
P2.5 Wild fish for nutrition (human consumption), benthic-round goby, ealpout	1.00	0.94	0.87	0.81	0.74	0.68	0.61	0.55	0.48	0.42	0.36
P3 Materials from algae	1.00	0.90	0.80	0.70	0.60	0.50	0.40	0.30	0.20	0.10	0.00
P4 Materials—wild fish and mussels—for agricultural use	1.00	0.93	0.86	0.80	0.73	0.66	0.59	0.52	0.46	0.39	0.32
P5 Plant-based energy resources	1.00	0.90	0.80	0.70	0.60	0.50	0.40	0.30	0.20	0.10	0.00
C1 Water environment for recreation	1.00	1.00	0.99	0.99	0.98	0.98	0.98	0.97	0.97	0.96	0.96
C2 Water environment for enjoyment of seascape	1.00	1.00	0.99	0.99	0.98	0.98	0.97	0.97	0.96	0.96	0.95
C3 Water environment for science and education	1.00	0.94	0.88	0.82	0.76	0.71	0.65	0.59	0.53	0.47	0.41
C4 Water environment for maintenance of cultural and historical heritage	1.00	1.00	1.00	0.99	0.99	0.99	0.99	0.98	0.98	0.98	0.98
C5 Water environment for spiritual experience	1.00	1.00	0.99	0.99	0.98	0.98	0.98	0.97	0.97	0.96	0.96
C6 Existence of habitats and species	1.00	0.95	0.90	0.85	0.81	0.76	0.71	0.66	0.61	0.56	0.51
Mean Ratio for all ES	**1.00**	**0.96**	**0.91**	**0.87**	**0.82**	**0.78**	**0.74**	**0.69**	**0.65**	**0.61**	**0.56**
Mean Ratio for ES with macroalgae habitat contribution >25%	**1.00**	**0.93**	**0.86**	**0.79**	**0.73**	**0.66**	**0.59**	**0.52**	**0.45**	**0.38**	**0.32**

Table A4. Supply of ES (ratio) depending on the protection extent of the mussel habitats. Source: The ES ratios are calculated, employing the ES assessment tool described in Armoskaite et al. (2020) [51], based on the reef habitat data for the study area. Notes: The contribution of the reef habitats to the ES supply is accounted as 100%, excluding contribution of other habitats (e.g., soft bottom habitats, pelagic habitats). The protection extent characterises the share of the mussel habitat area that is highly protected and, hence, preserved. A constant area for the other reef habitat types at 100% level is assumed. The ES ratio ranges from 0 to 1, where 1 shows the maximum possible ES supply by the reef habitats (e.g., when 100% of the area is preserved). The colours denote the ES ratio: 0–25, 25–50, 50–75, and 75–100.

ES provided by the reef habitats	**Preserved mussel habitat area by MPAs as a share of their total area**										
	100%	**90%**	**80%**	**70%**	**60%**	**50%**	**40%**	**30%**	**20%**	**10%**	**0%**
R1.1 Nutrient regulation (by denitrification)	1.00	0.98	0.95	0.93	0.90	0.88	0.85	0.83	0.80	0.78	0.75
R1.2 Nutrient regulation (by nutrient incorporation in biomass)	1.00	0.92	0.85	0.77	0.69	0.62	0.54	0.46	0.39	0.31	0.23
R2 Hazardous substances accumulation and transformation	1.00	0.92	0.83	0.75	0.66	0.58	0.49	0.41	0.32	0.24	0.15
R3 Carbon sequestration	1.00	0.93	0.86	0.79	0.73	0.66	0.59	0.52	0.45	0.38	0.31
P1 Wild algae for nutrition (human consumption)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
P2.1 Wild fish for nutrition (human consumption), pelagic-herring	1.00	0.99	0.98	0.97	0.95	0.94	0.93	0.92	0.91	0.90	0.89
P2.2 Wild fish for nutrition (human consumption), pelagic-sprat	1.00	0.91	0.81	0.72	0.63	0.53	0.44	0.34	0.25	0.16	0.06

P2.3 Wild fish for nutrition (human consumption), benthic-flounder	1.00	0.96	0.93	0.89	0.86	0.82	0.79	0.75	0.72	0.68	0.65
P2.4 Wild fish for nutrition (human consumption), benthic-cod	1.00	0.96	0.92	0.89	0.85	0.81	0.77	0.74	0.70	0.66	0.62
P2.5 Wild fish for nutrition (human consumption), benthic-round goby, ealpout	1.00	0.97	0.95	0.92	0.89	0.87	0.84	0.81	0.79	0.76	0.73
P3 Materials from algae	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
P4 Materials—wild fish and mussels—for agricultural use	1.00	0.98	0.95	0.93	0.91	0.88	0.86	0.84	0.81	0.79	0.77
P5 Plant-based energy resources	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
C1 Water environment for recreation	1.00	0.91	0.81	0.72	0.63	0.53	0.44	0.34	0.25	0.16	0.06
C2 Water environment for enjoyment of seascape	1.00	0.91	0.82	0.73	0.63	0.54	0.45	0.36	0.27	0.18	0.08
C3 Water environment for science and education	1.00	0.97	0.93	0.90	0.87	0.83	0.80	0.77	0.73	0.70	0.67
C4 Water environment for maintenance of cultural and historical heritage	1.00	0.90	0.81	0.71	0.61	0.52	0.42	0.32	0.23	0.13	0.03
C5 Water environment for spiritual experience	1.00	0.91	0.81	0.72	0.63	0.53	0.44	0.34	0.25	0.16	0.06
C6 Existence of habitats and species	1.00	0.96	0.92	0.88	0.84	0.80	0.76	0.72	0.68	0.64	0.60
Mean Ratio for all ES	**1.00**	**0.95**	**0.90**	**0.85**	**0.80**	**0.75**	**0.71**	**0.66**	**0.61**	**0.56**	**0.51**
Mean Ratio for ES with mussel habitat contribution >25%	**1.00**	**0.93**	**0.87**	**0.80**	**0.73**	**0.66**	**0.60**	**0.53**	**0.46**	**0.40**	**0.33**

Table A5. The list of benefits from the ES provided by the reef habitats. Notes: The given list of benefits was used in the first part of the survey for assessing the importance of the benefits of individual ES provided by the reef habitats. We have used the definition of the benefits according to Potschin and Haines-Young (2016) [76]: "The direct and indirect outputs from ecosystems that have been turned into products or experiences that are no longer functionally connected to the systems from which they were derived." Respondents were provided detailed description of each ES and related benefit. More succinct formulations are provided here. [1] These ES were grouped together into one ES for the assessment of importance of the benefits.

ES Provided by the Reef Habitats	Related Benefits
P1 Wild fish for nutrition (human consumption)	Food from wild sea fish for human consumption
P2 Wild algae for nutrition (human consumption) [1]	Materials from wild sea fish and macroalgae for various human needs
P3 Materials from algae [1]	
P4 Materials—wild fish and mussels—for agricultural use [1]	
P5 Plant-based energy resources [1]	
R1.1 Nutrient regulation	Quality of the water environment by assimilation of nutrient excess from human activities
R2 Hazardous substances accumulation and transformation	From hazardous polluting substances clean water environment for humans and marine animals
R3 Carbon sequestration	Improving atmospheric conditions by carbon capture and storage reducing carbon dioxide and other greenhouse gasses in the atmosphere
C1 Water environment for recreation	Feelings from leisure activities at the sea (supported by quality of the water environment)
C2 Water environment for enjoyment of seascape	Feelings from enjoyment of the sea scape (supported by quality of the water environment)
C3 Water environment for science and education	Education and obtaining new information (supported by quality of the water environment)

C4 Water environment for maintenance of cultural and historical heritage	Opportunities for visiting historical and cultural places, maintenance of the sea related traditions and culture (supported by quality of the water environment)
C5 Water environment for spiritual experience	Spiritual emotions and symbols, which create sense of place/belonging and identity, spiritual experience (supported by quality of the water environment)
C6 Existence of habitats and species	Moral satisfaction from and/or responsibility for existence and preservation for future generations of the marine habitats and related species

Q7. Please assess how important to you personally is each of the described benefit from the "services" provided to humans by the underwater macro-algae and mussel groves in the Latvian marine waters!

Please provide the assessment for each benefit in the 10 point scale, where 1 means "totally unimportant, 5 "moderate importance", 10 "very important".

Q7.1. How important for you personally is the following benefit provided by the underwater macro-algae and mussel groves?

Food from wild sea fish for human consumption

Humans use the sea fish in their daily diet. For Latvia such sea fish are important as herring, sprat, cod, flounder. The underwater perennial macro-algae and mussel groves provide environment necessary for their spawning and growth.

1 Totally unimportant	2	3	4	5 Moderate importance	6	7	8	9	10 Very important

Figure A1. An example of the question in the survey for assessing the importance of the benefits from individual ES provided the reef habitats.

State of "services" of underwater macro-algae groves

Economic activities, which create excess of nutrients and, hence, reduce water transparency (like fish farms in the sea), deteriorate conditions for macro-algae growth. New protected areas would ensure protection of the macro-algae in deep-sea waters from such negative impacts.

„Services" of macro-algae groves	**Possible states of „services" in 2030 depending on protection option**		
	Poor	**Rather good**	**Very good**
	Macro-algae groves are not protected.	30 % of macro-algae groves protected.	60 % of macro-algae groves protected.
☺ **[FISH]** Provides environment for fish spawning and growth. ☺ **[MATERIALS]** Can be used as raw material for various human needs. ☺ **[AIR]** Fix carbon, reducing carbon dioxide in the atmosphere. ☺ **[KNOWLEDGE]** Provides knowledge and new information. ☺ **[PRESERVATION]** Existence and preservation for future generations.	Decreased amount of macro-algae, declined quality of fish spawning and growth areas, reduced catch of herring.	Improved state of all "services", improved quality of fish spawning and growth areas, increased populations of herring and other fish for fisheries and human consumption.	Considerably improved state of all "services", considerably increased populations of fish (herring, cod), considerably increased amount of macro-algae for human uses.

Figure A2. Description of the attribute *State of ecosystem services provided by the deep-sea macroalgae groves* in the survey.

State of "services" of underwater mussel population

Economic activities, which physically destroy or sand rocky bottom of the sea (like wind farm construction works, fish farms in the sea), deteriorate conditions for mussel growth. New protected areas would ensure protection of the deep-sea mussel population from such negative impacts.

„Services" of mussel population	Possible states of „services" in 2030 depending on protection option		
☺ **[FISH]** Food for fish. ☺ **[WATER]** Maintain water clarity, securing quality of water environment for other plants and animals and humans' leisure. ☺ **[POLLUTION]** Accumulate hazardous substances, reducing pollution in water environment. ☺ **[KNOWLEDGE]** Provides knowledge and new information.	**Poor**	**Rather good**	**Very good**
	Mussel populations are not protected.	30 % of mussel populations protected.	60 % of mussel populations protected.
	Decreased amount of mussels, declined water clarity, increased level of harmful substance in fish.	Improved state of all "services", including improved water clarity, decreased frequency of blue-green algal blooming, decreased amount of harmful substances in the water environment and fish.	Considerably improved state of all "services", considerably increased fish diversity and size of populations, fish is absolutely safe to eat, very good water quality for leisure activities.

Figure A3. Description of the attribute *State of ecosystem services provided by the deep-sea mussel population* in the survey.

Negative impact on economic activities in the deep-sea

If new protected areas are not established, new economic activities will locate in areas where conditions will allow them deriving the highest income. This will create additional income to the economy of Latvia and new jobs for people.

New activities have restrictions in the protected areas – they have to implement special technologies that there are no negative impacts on the underwater plant groves, or they are completely forbidden in these areas. Locating new activities outside the protected areas will reduce space for the activities that already use the deep-sea waters.

Economic activities in the Latvian deep-sea waters	Possible impact on economic activities depending on protection option		
☺ CURRENT activities: fisheries. ☺ NEW activities expected in the future: wind farms, fish farms and mineral extraction.	**No negative impact**	**Negative impact on new activities**	**Negative impact on fisheries**
	No restrictions on activities. Largest possible additional income and jobs from new activities.	Smaller additional income and jobs from new activities.	Decreased jobs and income for fisheries.

Figure A4. Description of the attribute *Negative impact on economic activities in the deep-sea* in the survey.

Which of the given protection options do you prefer?

Characteristics	**State in 2030 without new protected areas**	**Option A**	**Option B**
State of **"services"** of **macro-algae** groves [FISH, MATERIALS, AIR, KNOWLEDGE, PRESERVATION]	Poor	Rather good	Very good
State of **"services"** of **mussel** population [FISH, WATER, POLLUTION, KNOWLEDGE , PRESERVATION]	Poor	Poor	Rather good
Negative impact on **economic activities in the deep-sea**	No negative impact	Impact on new activities	Impact on fisheries
Your Baltic Sea payment in 2020-2030	0 €	0.5 € per year (in total 5.5 €)	1 € per year (in total 11 €)

I prefer:

State in 2030 without new protected areas	☐
Option A	☐
Option B	☐

Figure A5. Example of a typical choice task.

Table A6. Classification of the responses, choosing *the status quo* alternative in all the choice tasks (n = 126), as protest responses or zero bids (based on data of a follow-up question).

Answer Options of a Follow-Up Question	**Zero Bid (No. of Responses)**	**Protest Response (No. of Responses)**
1. State without the new protected areas is satisfactory	5	
2. The other options had too high costs	6	
3. I cannot afford to pay for the other protection options	23	
4. Not having negative impact on the economic activities is more important for me	2	
5. Other problems than protection of the marine environment are more important	10	
6. I'm against introduction of the additional payment		31
7. I don't believe that the good state of macro-algae and mussel groves can be ensured		11
8. I don't believe that the money will be used for the planned purpose		31
9. Other reason. Please specify!		
Everyone should be responsible for their own actions, activities and production, instead of forbidding and then someone breaking the rules		1
The marine ecosystem is fully able to self-purify and recover itself, without additional investments		1
The payments must be made from the State budget	1	

Pensioners with the Latvian pension cannot be asked to pay, every euro is very important to us	1	
Why do people have to pay money for the sea because it is a state's problem	1	
The state must think about it	1	
I am not familiar with these issues		1
Total	**50**	**76**

Table A7. Representativeness of the survey sample for the final survey. Data are provided for the whole sample (n = 701) and for the sample, excluding protest responses (n = 625). Source: Data for the Latvian population concerning gender, age, administrative territory and nationality are taken from the Board of Citizenship and Migration Affairs (data on 1.1.2019). Data for the Latvian population concerning education and income comes from the Central Statistical Office (data for 2018).

Socio-demographic Characteristics of Respondents		**Latvian Population, Mean Share (%)**	**Survey Sample (n = 701), Mean Share (%)**	**Sample Excluding Protest Responses (n = 625), Mean Share (%)**
Gender	Male/Female	48.2/51.8	48.5/51.5	46.9/53.1
Age	18–24	8.7	8.8	9.3
	25–34	20.3	20.3	20.5
	35–44	19.3	19.3	19.0
	45–54	19.1	19.1	18.4
	55–63	17.5	17.4	17.9
	64–74	15.1	15.1	14.9
Region of Latvia	Rīga	33.4	33.2	33.0
	Pierīga	18.7	18.8	18.2
	Vidzeme	9.6	9.7	10.2
	Kurzeme	12.5	12.6	12.2
	Zemgale	11.8	11.7	12.0
	Latgale	13.9	14.0	14.4
Nationality	Latvian/Other	58.8/41.2	58.6/41.4	59.7/40.3
Education	Elementary education	9.4	9.1	8.8
	Vocational education	31.2	31.1	31.4
	High school	25.5	25.4	25.9
	Higher education (e.g., university)	33.9	34.4	33.9
Mean disposable income (per person per month)		546 EUR	544 EUR	550 EUR

Table A8. A mixed logit model results with socio-demographic interaction variables (n = 621; 76 protesters excluded from the sample, as well as 4 other respondents due to missing data for relevant interaction variables). Results of the mixed logit model with all tested interaction variables are available upon request.

Random Parameters	**Coefficient (Standard Error)**	**Significance (Z Value)**
ASCsq	−2.781 *** (0.335)	−8.31
State of services of macroalgae habitats: rather good	1.608 *** (0.398)	4.04
State of services of macroalgae habitats: very good	1.344 *** (0.425)	3.16
State of services of mussel habitats: rather good	2.161 *** (0.441)	4.90
State of services of mussel habitats: very good	1.866 *** (0.412)	4.53
Negative impact on economic activities in the deep-sea: fisheries	−0.941 ** (0.393)	−2.39
Negative impact on economic activities in the deep-sea: new activities	−0.601 * (0.341)	−1.76

Cost	−2.645 *** (0.123)	−21.42
Interaction Variables	**Coefficient (Standard Error)**	**Significance (Z Value)**
Income * State of services of macroalgae habitats: rather good	0.0013 *** (0.0003)	4.54
Income * State of services of macroalgae habitats: very good	0.0012 *** (0.0003)	3.66
Income * State of services of mussel habitats: rather good	0.001 *** (0.0003)	3.21
Income * State of services of mussel habitats: very good	0.0007 ** (0.0003)	2.46
Income * Negative impact on economic activities in the deep-sea: fisheries	−0.0004 (0.0003)	−1.53
Income * Negative impact on economic activities in the deep-sea: new activities	0.0001 (0.0003)	0.38
Age * State of services of macroalgae habitats: rather good	−0.009 (0.006)	−1.64
Age * State of services of macroalgae habitats: very good	−0.008 (0.006)	−1.3
Age * State of services of mussel habitats: rather good	−0.023 *** (0.006)	−3.71
Age * State of services of mussel habitats: very good	−0.018 *** (0.006)	−3.04
Age * Negative impact on economic activities in the deep-sea: fisheries	0.015 *** (0.006)	2.7
Age * Negative impact on economic activities in the deep-sea: new activities	0.010 ** (0.005)	2.07
Male * State of services of macroalgae habitats: rather good	−0.374 ** (0.184)	−2.04
Male * State of services of macroalgae habitats: very good	−0.447 ** (0.197)	−2.27
Male * State of services of mussel habitats: rather good	−0.120 (0.195)	−0.62
Male * State of services of mussel habitats: very good	−0.359 * (0.188)	−1.91
Male * Negative impact on economic activities in the deep-sea: fisheries	0.009 (0.182)	0.05
Male * Negative impact on economic activities in the deep-sea: new activities	0.017 (0.156)	0.11
Education * State of services of macroalgae habitats: rather good	−0.148 (0.097)	−1.52
Education * State of services of macroalgae habitats: very good	−0.012 (0.103)	−0.11
Education * State of services of mussel habitats: rather good	−0.058 (0.103)	−0.56
Education * State of services of mussel habitats: very good	0.059 (0.099)	0.60
Education * Negative impact on economic activities in the deep-sea: fisheries	−0.042 (0.096)	−0.43
Education * Negative impact on economic activities in the deep-sea: new activities	−0.116 (0.082)	−1.42
Standard Deviations for Random Parameters	**Coefficient (Standard Error)**	**Significance (Z Value)**
ASCsq	4.244 *** (0.357)	11.9
State of services of macroalgae habitats: rather good	−0.279 (0.292)	−0.95
State of services of macroalgae habitats: very good	0.083 (0.511)	0.16
State of services of mussel habitats: rather good	0.593 *** (0.204)	2.9
State of services of mussel habitats: very good	0.030 (0.212)	0.14
Negative impact on economic activities in the deep-sea: fisheries	0.741 *** (0.145)	5.12
Negative impact on economic activities in the deep-sea: new activities	0.053 (0.282)	0.19
Cost	1.918 *** (0.117)	16.33
Number of observations	11178	
Number of respondents	621	
Log-likelihood	−2790.3	
Bayesian information criterion	5953.4	
Akaike information criterion	5660.6	

The number of asterisks for coefficients indicates their level of statistical significance (i.e. the coefficients are significant at the 1% (***), 5% (**), or 10% (*) level).

Table A9. A mixed logit model results and marginal willingness-to-pay (WTP) estimates based on whole sample ($n = 701$), including the protest responses.

Random Parameters	Coefficient (Standard Error)	Significance (Z Value)	Mean WTP, EUR Per Person Per Year [95% Confidence Interval]
ASCsq	−2.580 *** (0.402)	−6.42	−4.82 [−6.47; −3.18]
State of services of macroalgae habitats: rather good	1.368 *** (0.099)	13.77	2.56 [1.77; 3.34]
State of services of macroalgae habitats: very good	1.452 *** (0.108)	13.4	2.71 [1.87; 3.55]
State of services of mussel habitats: rather good	1.470 *** (0.102)	14.43	2.75 [1.91; 3.59]
State of services of mussel habitats: very good	1.518 *** (0.102)	14.82	2.84 [1.97; 3.7]
Negative impact on economic activities in the deep-sea: fisheries	-0.633 *** (0.095)	−6.70	−1.18 [−1.66; −0.71]
Negative impact on economic activities in the deep-sea: new activities	−0.420 *** (0.077)	−5.48	−0.79 [−1.14; −0.43]
Cost	−2.593 *** (0.126)	−20.6	
Standard deviations for random parameters	**Standard deviation (standard error)**	**Significance**	
ASCsq	6.549 *** (0.487)	13.45	
State of services of macroalgae habitats: rather good	0.312 (0.313)	1.00	
State of services of macroalgae habitats: very good	−0.006 (0.484)	−0.01	
State of services of mussel habitats: rather good	0.559 *** (0.201)	2.78	
State of services of mussel habitats: very good	0.031 (0.229)	0.13	
Negative impact on economic activities in the deep-sea: fisheries	0.751 *** (0.142)	5.27	
Negative impact on economic activities in the deep-sea: new activities	0.054 (0.232)	0.23	
Cost	1.984 *** (0.086)	23.02	
Number of observations	12168		
Number of respondents	701		
Log-likelihood	−3009.1		
Bayesian information criterion	6169.3		
Akaike information criterion	6050.2		

The number of asterisks for coefficients indicates their level of statistical significance (i.e. the coefficients are significant at the 1% (***), 5% (**), or 10% (*) level). The cost is log-normal.

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