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Costs of degradation of the marine environment using the example of the German North Sea and Baltic Sea

Final Report

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Costs of degradation of the marine environment using the example of the German North Sea and Baltic Sea

Final Report

by

Dr. Malte Oehlmann, Anna-Catharina Nunes-Heinzmann
adelphi research, Berlin

Dr. Christine Bertram, Robert Hellwig
Ifw, Kiel

Eduard Interwies
InterSus, Berlin

Dr. Jürgen Meyerhoff
Selbstständiger Berater, Berlin

On behalf of the German Environment Agency

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Publisher
Umweltbundesamt
Wörlitzer Platz 1
06844 Dessau-Roßlau
Tel: +49 340-2103-0
Fax: +49 340-2103-2285
buergerservice@uba.de
Internet: www.umweltbundesamt.de

/umweltbundesamt.de
/umweltbundesamt

Report performed by:
adelphi research gemeinnützige GmbH
Alt-Moabit 91
10559, Berlin
Germany

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Edited by:
Section II 2.1 Übergreifende Angelegenheiten Wasser und Boden
Dirk Osiek (Fachbegleitung)

Section II 2.3 Meeresschutz
Andrea Weiß (Fachbegleitung)

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Abstract: The value of the German marine environment

Europe's coasts and marine waters, including the North Sea and the Baltic Sea, are among the most intensively exploited marine areas in the world. Common uses of the two seas include fishing, shipping and tourism, which are important economic activities, but also put pressure on the marine environment. Within this project, we estimate the benefits for the German population that would be generated if a "Good Environmental Status"(As defined in the Marine Strategy Framework Directive (MSFD), which was adopted by the European Union (EU) in June 2008 (EU 2008) was achieved in the German marine waters, i.e., the German parts of the North Sea and the Baltic Sea. To this end we derive the willingness to pay (WTP) of the German population for reaching a GES in the German marine environment using the contingent valuation method (CVM). In addition to the CVM, a choice experiment (CE) was included in the survey and positioned after the CVM scenario and follow-up questions. The analysis of the contingent valuation was performed by using three different models based on different subsets of the sampled data. One of the basic models was calculated by using OLS estimation. The second basic model is a Tobit Model, which is used to predict the intervals chosen by survey participants. Due to the low explanatory power of these basic models, a Double Hurdle Model was selected as a third approach for an extended analysis of Germans' WTP. The starting point for the analysis of the choice data is the random utility model (RUM) (McFadden's 1974). Building on assumptions with regard to the error terms one gets the conditional logit (CL) model. Given that the CL model assumes that all individuals have the same preferences, we also apply a latent class (LC) model which allows us to capture unobserved heterogeneity in taste sensitivities.We find that the aggregate benefits of reaching GES in the German North and Baltic Sea by 2040 amount to 3.908 billion EUR per year for the basic interval regression model (mean WTP = 56,24 EUR) excluding protest responses and to 4.566 billion EUR per year for the basic OLS regression model (mean WTP = 65,71 EUR) excluding protest responses. Mean individual WTP estimated from the double hurdle model amounts to 61.6 EUR per person and year, resulting in mean aggregate benefits of reaching GES in the German North and Baltic Sea by 2040 that amount to 2.889 million EUR per year.

Kurzbeschreibung: Kosten der Verschlechterung der Meeresumwelt am Beispiel der deutschen Nord- und Ostsee

Die europäischen Küsten und Meeresgewässer, einschließlich der Nord- und Ostsee, gehören zu den am intensivsten genutzten Meeresgebieten der Welt. Zu den gängigsten Nutzungsarten der beiden Meere gehören Fischerei, Schifffahrt und Tourismus, die wichtige wirtschaftliche Aktivitäten darstellen, aber auch Druck auf die Meeresumwelt ausüben. Im Rahmen dieses Projektes schätzen wir den Nutzen für die deutsche Bevölkerung ab, der entstehen würde, wenn in den deutschen Meeresgewässern, d.h. den deutschen Teilen von Nord- und Ostsee, ein "Guter Umweltzustand" (wie in der Meeresstrategie-Rahmenrichtlinie (MSFD) definiert, die im Juni 2008 von der Europäischen Union (EU) verabschiedet wurde (EU 2008)) erreicht würde. Dazu leiten wir die Zahlungsbereitschaft (willingness-to-pay, WTP) der deutschen Bevölkerung für das Erreichen eines GES in der deutschen Meeresumwelt mit Hilfe der Contingent Valuation Methode (CVM) ab. Zusätzlich zum CVM wurde ein Choice-Experiment (CE) in die Befragung aufgenommen. Die Analyse der kontingenten Bewertung wurde mit Hilfe von drei verschiedenen Modellen durchgeführt, die auf unterschiedlichen Teilmengen der Stichprobendaten basieren. Eines der Grundmodelle wurde mit Hilfe einer OLS-Schätzung berechnet. Das zweite Grundmodell ist ein Tobit-Modell, das zur Vorhersage der von den Umfrageteilnehmern gewählten Intervalle verwendet wird. Aufgrund der geringen Erklärungskraft dieser Basismodelle wurde als dritter Ansatz für eine erweiterte Analyse des WTP der Deutschen ein "Double Hurdle" - Modell gewählt. Ausgangspunkt für die Analyse der Choice-Daten ist das Random-Utility-Modell (RUM) (McFadden's 1974). Aufbauend auf Annahmen bezüglich der Fehlerterme erhält man das bedingte Logit (CL)-Modell. Da das CL-Modell davon ausgeht, dass alle Individuen die gleichen Präferenzen haben, wenden wir auch ein "Latent Class" - Modell (LC) an, das es uns erlaubt, unbeobachtete Heterogenität in den Geschmacksempfindlichkeiten zu erfassen. Es zeigt sich, dass der aggregierte Nutzen des Erreichens eines GES in der deutschen Nord- und Ostsee bis 2040 3,908 Mrd. EUR pro Jahr für das grundlegende Intervall-Regressionsmodell (durchschnittliche Zahlungsbereitschaft = 56,24 EUR) ohne Protestantworten und 4,566 Mrd. EUR pro Jahr für das grundlegende OLS-Regressionsmodell (durchschnittliche Zahlungsbereitschaft = 65,71 EUR) ohne Protestantworten beträgt. Die mit dem "Double Hurdle" - Modell geschätzte mittlere individuelle Zahlungsbereitschaft beträgt 61,6 EUR pro Person und Jahr, was zu einem mittleren Gesamtnutzen des Erreichens eines GES in der deutschen Nord- und Ostsee bis 2040 führt, der sich auf 2,889 Mrd. EUR pro Jahr beläuft.

Table of content

List of figures

List of tables

List of abbreviations

BIC	Bayesian Information Criteria
CBM	Contingent Behavior Method
CL	Conditional Logit
CVM	Contingent Valuation Method
DCE	Discrete Choice Experiments
EC	European Commission
EU	European Union
ES	Ecosystem Services
ESA	Economic and Social Analyses Network
GES	Good Environmental Status
HOLAS	Holistic Assessment of the Ecosystem Health of the Baltic Sea
ICG	Intersessional Correspondence Group
LC	Latent Class
LN	Natural Logarithm
MS	Member States
MSFD	Marine Strategy Framework Directive
POMESA	Programme of Measures and Economic and Social Analysis
RUM	Random Utility Model
TCM	Travel Cost Method
UK	United Kingdom
WFD	Water Framework Directive

Summary

General setting

Europe's coasts and marine waters, including the North Sea and the Baltic Sea, are among the most intensively exploited marine areas in the world. As is the case with most inland waters, different interests of use and conservation goals overlap in these areas. Common uses of the two seas include fishing, shipping and tourism, which are important economic activities, but also put pressure on the marine environment. As a consequence, the Marine Strategy Framework Directive (MSFD) was adopted by the European Union (EU) in June 2008 (EU 2008). The objective of the MSFD is to achieve a "Good Environmental Status" (GES) of European marine waters. The regulatory framework of the MSFD requires the member states (MS) to develop marine strategies in close collaboration with one another. These strategies have to describe the current status as well as the target for the marine environmental status including a list of instruments and measures for achieving the GES.

Against this background, the initial assessment of the status of the German marine waters, i.e. the German areas of the North Sea and Baltic Sea, was carried out in Germany in 2012. The status assessment was updated in 2018, examining the relevant pressures and the status in terms of species, habitats and ecosystems. However, due to a lack of data and in contrast to some other countries, a concrete quantification of the costs of degradation of the marine environment has not yet been carried out in Germany (BMU 2018a, b).

Although the MSs committed themselves initially to reaching GES in their territorial marine waters until 2020, this goal has not been met by all countries for all environmental descriptors. The second cycle of implementation of the MSFD thus officially started in 2018 but is suffering from delays in reporting (EC 2020a).

In the course of the next reporting cycle of the MSFD, all MS will have to prepare an updated assessment of the status of their marine waters until 2024. The aim of this project is to contribute to the German status assessment report due in 2024 by estimating the cost of degradation of the German marine environment should GES not be met. In this context, Germany follows the thematic approach, which assumes that the costs of degradation of the marine environment can be derived from the difference between the good status of the marine environment (= reference condition/GES) and the current status (= actual status). The costs of degradation are then approximated by the loss of benefits resulting from the fact that the GES has not yet been achieved (EC 2018).

Within this project, we estimate the benefits for the German population that would be generated if GES was achieved in the German marine waters, i.e., the German parts of the North Sea and the Baltic Sea. To this end, we closely follow Nieminen et al. (2019) and Nordzell et al. (2020) and derive the willingness-to-pay (WTP) of the German population for reaching a GES in the German marine environment using the contingent valuation method (CVM).

Valuation method survey design and implementation

The aim of the project was to assess the total economic benefit of reaching GES in the German marine waters as defined by the MSFD. Since it was the aim to cover use values as well as non-use values with the benefit estimates, a stated preference method was chosen. Former research

has shown that a considerable part of the total economic benefit of changes in the marine environment is rooted in non-use values (Ahtiainen et al. 2014). In addition to the CVM, a choice experiment (CE) was included in the survey and positioned after the CVM scenario and follow-up questions. The reasons for including a CE were twofold. Firstly, the CVM allows valuing changes in a comprehensive bundle of attributes, but only for one fixed scenario and not for individual level changes among attributes. Since there was a policy interest to also get an understanding of the relative importance of the different descriptors, the DCE was included in addition to the CVM. Secondly, the benefit estimates resulting from the CVM should be validated by means of including the discrete choice experiments (DCE).

The survey was designed following the example provided by Nieminen et al. (2019), but was adapted to match German circumstances. Thus, we had to account for the fact that German marine waters comprised the North Sea in addition to the Baltic Sea or the fact that respondents in Germany live on average further away from the coast.

The survey consisted of five parts:

1. Previous use of and general relationship to the North Sea and Baltic Sea: Given the complex nature of the valuation task to follow, this part of the survey was designed to familiarize respondents with the topic and gather general data regarding leisure behavior pertaining to the German coasts.
2. Current status of the German marine waters: Due to the large complexity of the environmental issues, the eleven descriptors presented in the MSFD were grouped into six environmental problems following Nieminen et al. (2019) (see Figure Figure 1 Descriptors used in the survey and original descriptors according to the MSFD) which were described briefly but comprehensively to the respondents. After each short presentation, the respondents were asked how familiar they had been with the respective environmental problem before taking the survey.
3. Valuation scenario: This included a brief description of the political background, the aim of reaching GES and the need to finance measures to reach GES, which was followed by questions on respondents WTP using different payment vehicles. The valuation scenario was followed by questions on reasons for being willing or not being willing to pay, the relative importance of the environmental problems, security about the amount of WTP, consequentiality of the valuation question, and understanding of the task.
4. Presentation of the DCE: We briefly introduced the DCE to the respondents by highlighting the possibility that GES would not be reached uniformly across all environmental problems. The options of the DCE were designed such that different environmental problems could be reached to different extents. These extents were described quantitatively using percentages as suggested in recent studies on the state-of-the-art in contingent valuation (Johnston et al. 2017).
5. General information about socio-demographic background and environmental attitudes. In addition, we added questions on the anticipated effects of the COVID-19 pandemic on the respondents.

The survey was implemented in to waves. The first wave (main survey) was implemented in March and April 2020. Norstat offers a high-quality online panel characterized, e.g., by offline recruiting and a low frequency of invitations to surveys for the single respondents. The second wave (control survey) was conducted in September 2020. Besides some additional control questions, the same questionnaire of the first wave was used. The main objective of

implementing a second wave was to investigate whether the COVID19-pandamic influenced survey results.

Econometric approach

The analysis of the contingent valuation was performed by using three different steps of data analysis. In total three different models were calculated based on different subsets of the sampled data. One of the basic models was calculated by using ordinary least square estimation to model the stated WTP given by participants in the open ended question. The second basic model is a Tobit Model used to predict the intervals chosen by survey participants. Due to the low explanatory power of these basic models, a Double Hurdle Model was selected as a third approach for an extended analysis of Germans' WTP.

The starting point for the analysis of the choice data is the random utility model (RUM) (McFadden's 1974). Building on assumptions with regard to the error terms one gets the conditional logit (CL) model. To capture unobserved heterogeneity in taste sensitivities we also apply a latent class (LC) model.

Results Main Survey – First Wave

Descriptive statistics

- Socio-demographic characteristics of the sample

The average respondent has a net monthly household income of 2,587 EUR. The standard deviation was quite high (1,230 EUR) showing that income varies greatly across the sample. The same is true for the participants' age, which ranges between 18 and 86 years, and averaged 49.6 years. Furthermore, the sample consists of slightly more women than men (51.2 percent) and about 21.1 percent of all participants have undergone higher education, meaning that they had obtained a university degree. With regard to household size, the average household consists of 2.3 people with 0.3 being minors.

- Travel behaviour

The mean distance between the place of residence of the respondent and the closest coastal town to either the North or Baltic Sea was measured to be 296.3 km with a standard deviation of 171.5 km. The maximum distance was 687.3 km.

The majority of the respondents had been at the German coasts at least once during the last five years (53.2 percent). Roughly one third (30.3 percent) of the respondents stated that they had been there more than five years ago, and the remaining 16.6 percent stated that they had never visited the German coasts for spending leisure time there. In total, the overwhelming majority (83%) had been to the German marine waters.

Almost all respondents (96.9 percent) responded that they had visited the coast for enjoying nature and the landscape. The second most often mentioned activity was spending time at the beach (including sunbathing, walking, running and cycling at the beach), which was mentioned by 93.8 percent of the respondents.

Respondents who indicated that they had visited the German marine waters at least once in the past (N=874) were then directed to a set of questions asking more details about their last trip to the German coast. Firstly, these respondents were asked whether they had last spent leisure

time at the North Sea or at the Baltic Sea. 405 respondents (46.3 percent) indicated that they had last visited the North Sea and 459 respondents (52.5 percent) indicated that they had last visited the Baltic Sea for leisure purposes; the rest did not remember.

Furthermore, all respondents were asked to state their preferences on different travel destinations which can be considered substitutes to spending time at the German coasts. The majority of the respondents would rather spend time at the German coast compared to all three alternatives mentioned (foreign seas, forest, and lakes).

- Knowledge about environmental problems and perceived importance

Regarding the knowledge of the six environmental problems, the most well-known environmental problems were observed to be physical impacts and waste, with 30.4 percent of the respondents indicating to have heard a lot about them and only 17.4 percent of the respondents indicating to have never heard about them. The least well-known environmental problem was the introduction of non-indigenous species, with only 16.2 percent of the respondents indicating to have heard a lot about it and 38.4 percent of the respondents indicating to have never heard about it. Regarding the perceived importance of the single environmental problems (Figure 9), it can be observed that it corresponds to some extent to the knowledge about the problems. For example, the least well-known problem, arrival of non-indigenous species, is also considered the least important environmental problem. All other environmental problems are considered to be "very important" by between 60 percent and 80 percent of the respondents.

- Importance of cultural ecosystem services

Respondents in the survey were asked to select and rank the three most important reasons to value the environment of the North and Baltic Sea. The list of reasons was designed to summarize and represent the most important cultural ecosystem services (ES) provided by coastal environments (Ahtiainen et al. 2019). The two most important cultural ES provided by the coasts of the North and Baltic Sea reported by survey respondents were i.) to enjoy the landscape and ii.) to spend leisure time and recreate at the coast with 926 and 780 respondents mentioning them among their three most important cultural ES, respectively.

- Willingness to pay

Of all participants who made it into the final sample (N =1,063) about 51 percent stated that they were in general willing to pay something to reach GES, 30 percent reported that they were undecided while 18 percent refused to make any contribution. After the general screening question willingness to pay for the achievement of the GES in the German marine waters was measured in two distinct ways. First, respondents were asked to select one out of 18 intervals from a payment card. This allowed determining the lower and upper bound of their WTP. The mean lower bound was 33.3 EUR and the upper bound averaged 46.8 EUR. In a second step, participants were asked to state the exact amount they would be willing to pay in an open-ended question. Here, people stated that they were willing to pay 34.8 EUR on average.

The majority of people who were unwilling to contribute monetarily to the achievement of GES stated that they could simply not afford to make a contribution (29 percent). This was corroborated by the fact that these respondents had an income which was well below the mean income of other survey participants.

Of those who stated a general WTP, about 39 percent expressed that their motivation was rooted in a concern for future generations. A third of the respondents ascribed their WTP to a general appreciation for habitats, suggesting that they were motivated primarily by concerns about biological diversity. Motivations related to the personal use of the seas as recreational area were expressed by a much smaller percentage of people (13 percent).

Regression results

- Determinants of WTP

In total two sets of models were estimated to analyze the determinants of WTP and to predict mean WTP and confidence intervals for aggregate WTP of the general population in Germany. Firstly, we implemented basic OLS and interval regression models to explain WTP. The dependent variables of these models were the natural logarithm (ln) of WTP_merged and WTP_interval, respectively.

Secondly, we implemented advanced modelling approaches to explain and predict WTP. We used a double hurdle model which assumes that investing in a good or a service – here WTP to achieve GES – is explained by two different processes: First, the individual decides whether to participate in the market at all, i.e., whether she / he is in general willing to pay something. Passing this hurdle, the individual makes a decision about the quantity to consume, i.e., how much he or she is willing to pay (Gracia 2013, Crag 1971). Note that the second process still can explain a WTP of zero (second hurdle). Separating the decision process in two parts allows us to use different variables to explain each decision.

Overall, most effects are very similar across the models. It can be noted that WTP significantly increases with increasing income, with increasing household size, and if the respondents had obtained higher education, i.e., a university degree. In contrast, WTP decreases with the age of the respondent. However, this effect is only found to be significant in the models including protest respondents. No significant effects are observed with respect to gender and, interestingly, the distance to the coast.

For the double hurdle model, we find that the higher the age of the respondent, the lower the probability to participate in the market, i.e., to state a positive WTP to achieve GES. In contrast, the probability to participate in the market increases with the knowledge about the six environmental problems mentioned in the survey. Concerning the determinants of the WTP amount, we find that the amount respondents are willing to spend to achieve GES increases with income. The same effect is observed for the number of people living in the household and the knowledge about the environmental problems in the North and Baltic Sea.

- Aggregate consumer surplus estimates

Multiplying the mean WTP with the total adult population in Germany (69.5 million people as of December 31, 2019), the aggregate benefits of reaching GES in the German North and Baltic Sea by 2040 amount to 3.908 billion EUR per year for the basic interval regression model (mean WTP = 56,24 EUR) excluding protest responses and to 4.566 billion EUR per year for the basic OLS regression model (mean WTP = 65,71 EUR) excluding protest responses.

Mean individual WTP estimated from the double hurdle model amounts to 61.6 EUR per person and year, resulting in mean aggregate benefits of reaching GES in the German North and Baltic Sea by 2040 that amount to 2.889 billion EUR per year.

- Discrete choice experiment

For the latent class model WTP measures are presented in EUR per year and household to fully achieve GES, i.e., by 100% in 2040. On each of the six choice sets participant could choose between a status quo and two alternative states of the future. Each alternative was composed of the environmental problems. Their levels – 0% (as today), 30%, 60% and 100% - indicated the share to which GES is achieved in 2040. We find that class 1 is much smaller than class 2. On average, the likelihood of being assigned to this class is 0.74 percent compared to only 26 percent for class 1. Also, preferences indeed differ across classes. Respondents in class 1 are not willing to pay to achieve GES whereas WTP is estimated to be significant and positive for all attributes in class 2. WTP is quite similar for the seven environmental problems analyzed ranging from 107 EUR (eutrophication) to 76 EUR (physical impacts).

Results control survey – Second wave

A second survey wave was conducted in order to control for possible impact of the global COVID19 pandemic on participants WTP. The survey design and methodology followed the same logic as in the first wave. With regards to the results, the distribution of people's general WTP for the GES of the German marine waters was almost identical to the first wave. However, the WTP is slightly lower, though not statistically significant, in the second wave both for the OLS and interval regression, interval and double hurdle models, as well as the DCE.

Zusammenfassung

Ausgangssituation

Die europäischen Küsten und Meeresgewässer, einschließlich der Nord- und Ostsee, gehören zu den am intensivsten genutzten Meeresgebieten der Welt. Wie bei den meisten Binnengewässern überschneiden sich auch in diesen Gebieten unterschiedliche Nutzungsinteressen und Schutzziele. Zu den gängigsten Nutzungsarten der beiden Meere gehören Fischerei, Schifffahrt und Tourismus. Diese stellen jeweils wichtige wirtschaftliche Aktivitäten dar, üben jedoch auch Druck auf die Meeresumwelt aus. Als Konsequenz wurde von der Europäischen Union (EU) im Juni 2008 die Meeresstrategie-Rahmenrichtlinie (MSFD) verabschiedet (EU 2008). Das Ziel der MSFD ist es, einen „guten Umweltzustand" (Good Environmental Status, GES) für die europäischen Meeresgewässer zu erreichen. Der Regelungsrahmen der MSFD verlangt von den Mitgliedsstaaten (MS), in enger Zusammenarbeit Meeresstrategien zu entwickeln. Diese Strategien müssen sowohl den Ist-Zustand, als auch das Ziel für den marinen Umweltzustand einschließlich einer Liste von Instrumenten und Maßnahmen zur Erreichung des GES beschreiben.

Vor diesem Hintergrund wurde in Deutschland 2012 die erste Zustandsbewertung der deutschen Meeresgewässer, also der deutschen Bereiche von Nord- und Ostsee, durchgeführt. Die Zustandsbewertung wurde im Jahr 2018 aktualisiert, wobei die relevanten Belastungen und der Zustand in Bezug auf Arten, Lebensräume und Ökosysteme untersucht wurden. Eine konkrete Quantifizierung der Kosten der Degradation der Meeresumwelt wurde in Deutschland jedoch aufgrund fehlender Daten und im Gegensatz zu einigen anderen Ländern bisher nicht durchgeführt (BMU 2018a, b).

Obwohl sich die MS ursprünglich verpflichtet hatten, bis 2020 einen GES in ihren territorialen Meeresgewässern zu erreichen, wurde dieses Ziel nicht von allen Ländern für alle Umweltdeskriptoren erreicht. Der zweite Zyklus der Umsetzung der MSRL hat offiziell im Jahr 2018 begonnen, leidet aber unter Verzögerungen bei der Berichterstattung (EC 2020a).

Im Zuge des nächsten Berichtszyklus der MSFD müssen alle MS eine aktualisierte Bewertung des Zustands ihrer Meeresgewässer bis 2024 erstellen. Ziel dieses Projekts ist es, einen Beitrag zu dem 2024 fälligen deutschen Zustandsbewertungsbericht zu leisten, indem die Kosten der Verschlechterung der deutschen Meeresumwelt bei Nichterfüllung des GES abgeschätzt werden. Deutschland folgt dabei dem thematischen Ansatz, der davon ausgeht, dass sich die Kosten der Degradation der Meeresumwelt aus der Differenz zwischen dem guten Zustand der Meeresumwelt (= Referenzzustand/GES) und dem aktuellen Zustand (= Ist-Zustand) ableiten lassen. Die Kosten der Degradation werden dann näherungsweise durch den entgangenen Nutzen, der sich aus der Tatsache ergibt, dass der GES noch nicht erreicht wurde, bestimmt (EC 2018).

Im Rahmen dieses Projekts schätzen wir den Nutzen für die deutsche Bevölkerung ab, der entstehen würde, wenn GES in den deutschen Meeresgewässern, d. h. den deutschen Teilen der Nord- und Ostsee, erreicht würde. Dabei orientieren wir uns eng an der Arbeit von Nieminen et al. (2019) und Nordzell et al. (2020) und leiten die Zahlungsbereitschaft (willingness-to-pay, WTP) der deutschen Bevölkerung für das Erreichen eines GES in der deutschen Meeresumwelt mit Hilfe der „Contingent Valuation"-Methode (CVM) ab.

Schätzmethode, Umfragedesign und Implementierung

Ziel des Projekts war es, den ökonomischen Nutzen des Erreichens des GES in den deutschen Meeresgewässern gemäß der MSFD zu bewerten. Da es das Ziel war, sowohl Nutzungswerte als auch Nicht-Nutzungswerte mit den Nutzenschätzungen zu erfassen, wurde eine „Stated Preference"-Methode gewählt. Frühere Untersuchungen haben gezeigt, dass einem beträchtlichen Anteil des ökonomischen Nutzens von Veränderungen in der Meeresumwelt Nicht-Nutzungswerte zu Grunde liegen (Ahtiainen et al. 2014). Zusätzlich zum CVM wurde ein Choice-Experiement (CE) in die Umfrage aufgenommen. Die Einbeziehung eines CE war dabei zum einen darin begründet, dass die CVM die Bewertung von Veränderungen in einem umfassenden Bündel von Attributen erlaubt, dies aber nur für ein festes Szenario und nicht für Veränderungen einzelner Attribute. Da ein politisches Interesse daran bestand, auch ein Verständnis für die relative Bedeutung der verschiedenen Deskriptoren zu erhalten, wurde das DCE zusätzlich zum CVM einbezogen. Zum anderen, sollten die aus dem CVM resultierenden Nutzenabschätzungen durch die Einbeziehung der Discrete-Choice-Experimente (DCE) validiert werden.

Die Umfrage wurde nach dem Vorbild von Nieminen et al. (2019) konzipiert, aber an die deutschen Verhältnisse angepasst. So musste bspw. berücksichtigt werden, dass die deutschen Meeresgewässer neben der Ostsee auch die Nordsee umfassen oder, dass die Befragten in Deutschland im Durchschnitt weiter von der Küste entfernt leben.

Die Umfrage bestand aus fünf Teilen:

1. Bisherige Nutzung und allgemeine Beziehung zu Nord- und Ostsee: Angesichts der Komplexität der folgenden Bewertungsaufgabe diente dieser Teil der Befragung dazu, die Befragten mit dem Thema vertraut zu machen und allgemeine Daten zum Freizeitverhalten an den deutschen Küsten zu erheben.
2. Aktueller Zustand der deutschen Meeresgewässer: Aufgrund der großen Komplexität der Umweltprobleme wurden die elf Deskriptoren der MSFD in Anlehnung an Nieminen et al. (2019) zu sechs Umweltproblemen zusammengefasst (siehe Abbildung 1: In der Befragung verwendete Deskriptoren und Originaldeskriptoren nach MSFD), die den Befragten kurz, aber verständlich beschrieben wurden. Nach jeder Kurzpräsentation wurden die Befragten gefragt, wie vertraut sie mit dem jeweiligen Umweltproblem vor Beginn der Befragung waren.
3. Bewertungsszenario: Dieses umfasste eine kurze Beschreibung des politischen Hintergrunds, des Ziels den GES zu erreichen, und der Notwendigkeit, Maßnahmen zur Erreichung des GES zu finanzieren, worauf Fragen zur Zahlungsbereitschaft der Befragten unter Verwendung verschiedener Zahlungsmittel folgten. Dem Bewertungsszenario folgten Fragen zu den Gründen für die Zahlungsbereitschaft bzw. Nicht-Zahlungsbereitschaft, der relativen Wichtigkeit der Umweltprobleme, der Sicherheit über die Höhe der Zahlungsbereitschaft, der Bedeutung der Bewertungsfrage und dem Verständnis der Aufgabe.
4. Präsentation des DCE: Das DCE wurde den Befragten kurz vorgestellt, indem die Möglichkeit betont wurde, dass ein GES nicht gleichmäßig über alle Umweltprobleme hinweg erreicht werden könnte. Die Optionen des DCE wurden so gestaltet, dass verschiedene Umweltprobleme in unterschiedlichem Ausmaß erreicht werden. Diese Ausmaße wurden quantitativ mit Prozentsätzen beschrieben, wie es in aktuellen Studien zum Stand der Technik in der kontingenten Bewertung vorgeschlagen wird (Johnston et al. 2017).

5. Allgemeine Informationen zum soziodemografischen Hintergrund und zu Umwelteinstellungen. Zusätzlich haben wir Fragen zu den erwarteten Auswirkungen der COVID-19-Pandemie auf die Befragten hinzugefügt.

Die Umfrage wurde in zwei Wellen durchgeführt. Die erste Welle (Haupterhebung) wurde im März und April 2020 durchgeführt. Norstat bietet ein qualitativ hochwertiges Online-Panel an, das sich u. a. durch Offline-Rekrutierung und eine geringe Einladungshäufigkeit der einzelnen Befragten auszeichnet. Die zweite Welle (Kontrollbefragung) wurde im September 2020 durchgeführt. Neben einigen zusätzlichen Kontrollfragen wurde der gleiche Fragebogen wie in der ersten Welle verwendet. Das Hauptziel der Durchführung einer zweiten Welle war es, zu untersuchen, ob die COVID19-Pandemie die Umfrageergebnisse beeinflusst.

Ökonometrischer Ansatz

Die Analyse der „contingent valuation“ wurde mit Hilfe von drei verschiedenen Schritten der Datenanalyse durchgeführt. Insgesamt wurden drei verschiedene Modelle auf der Grundlage verschiedener Teilmengen der Stichprobendaten berechnet. Eines der Basismodelle wurde mit Hilfe der gewöhnlichen Kleinste-Quadrate-Methode geschätzt, um die von den Teilnehmern in der offenen Frage angegebene Zahlungsbereitschaft zu modellieren. Das zweite Grundmodell ist ein Tobit-Modell, das verwendet wurde, um die von den Umfrageteilnehmern gewählten Intervalle vorherzusagen. Aufgrund der geringen Erklärungskraft dieser Basismodelle wurde ein „Double Hurdle“-Modell als dritter Ansatz für eine erweiterte Analyse der Zahlungsbereitschaft der deutschen Bevölkerung gewählt.

Ausgangspunkt für die Analyse der „Choice“-Daten ist das Random-Utility-Modell (RUM) (McFadden's 1974). Aufbauend auf Annahmen bezüglich der Fehlerterme erhält man das bedingte Logit-Modell (CL). Um unbeobachtete Heterogenität in den Geschmacksempfindlichkeiten zu erfassen, verwenden wir zusätzlich ein latentes Klassenmodell („latent class (LC) model“).

Ergebnisse Hauptumfrage - Erste Welle

<u>Deskriptive Statistik</u>

- Soziodemografische Merkmale der Stichprobe

Der durchschnittliche Befragte hat ein monatliches Haushaltsnettoeinkommen von 2.587 EUR. Die Standardabweichung war recht hoch (1.230 EUR), was zeigt, dass das Einkommen innerhalb der Stichprobe stark variiert. Das Gleiche gilt für das Alter der Teilnehmer, das zwischen 18 und 86 Jahren liegt und im Durchschnitt 49,6 Jahre beträgt. Darüber hinaus besteht die Stichprobe aus etwas mehr Frauen als Männern (51,2 %) und etwa 21,1 % aller Teilnehmer haben eine höhere Ausbildung, d.h. einen Hochschulabschluss, absolviert. Hinsichtlich der Haushaltsgröße besteht der durchschnittliche Haushalt aus 2,3 Personen, wobei 0,3 Personen minderjährig sind.

- Reiseverhalten

Die mittlere Entfernung zwischen dem Wohnort der Befragten und dem nächstgelegenen Küstenort an der Nord- oder Ostsee wurde mit 296,3 km bei einer Standardabweichung von 171,5 km gemessen. Die maximale Entfernung betrug 687,3 km.

Die Mehrheit der Befragten war in den letzten fünf Jahren mindestens einmal an den deutschen Küsten (53,2 %). Etwa ein Drittel (30,3 %) der Befragten gab an, vor mehr als fünf Jahren dort

gewesen zu sein, und die restlichen 16,6 % gaben an, die deutschen Küsten noch nie besucht zu haben, um dort ihre Freizeit zu verbringen. Insgesamt war die überwiegende Mehrheit (83 %) schon einmal an den deutschen Meeresgewässern.

Fast alle Befragten (96,9 %) antworteten, dass sie die Küste besucht haben, um die Natur und die Landschaft zu genießen. Die am zweithäufigsten genannte Aktivität war das Verbringen von Zeit am Strand (einschließlich Sonnenbaden, Spazierengehen, Laufen und Radfahren am Strand). Diese Aktivität wurde von 93,8 % der Befragten angegeben.

Die Befragten, die angaben, in der Vergangenheit mindestens einmal die deutschen Meeresgewässer besucht zu haben (N=874), wurden anschließend zu einer Reihe von Fragen geleitet, in denen nähere Angaben zu ihrer letzten Reise an die deutsche Küste abgefragt wurden. Zunächst wurde gefragt, ob sie ihre Freizeit zuletzt an der Nord- oder an der Ostsee verbracht haben. 405 Befragte (46,3 %) gaben an, zuletzt an der Nordsee gewesen zu sein und 459 Befragte (52,5 %) gaben an, zuletzt zu Freizeitzwecken an der Ostsee gewesen zu sein; der Rest konnte sich nicht erinnern.

Darüber hinaus wurden alle Befragten gebeten, ihre Präferenzen für verschiedene Reiseziele anzugeben, die als Ersatz für einen Aufenthalt an den deutschen Küsten in Frage kommen. Die Mehrheit der Befragten würde im Vergleich zu allen drei genannten Alternativen (fremde Meere, Wald und Seen) lieber Zeit an der deutschen Küste verbringen.

- Wissen über Umweltprobleme und wahrgenommene Wichtigkeit

Hinsichtlich der Kenntnis der sechs Umweltprobleme wurden physikalische Einwirkungen und Abfall als das bekannteste Umweltproblem identifiziert, wobei 30,4 % der Befragten angaben, viel darüber gehört zu haben und nur 17,4 % der Befragten angaben, noch nie davon gehört zu haben. Das am wenigsten bekannte Umweltproblem war die Einführung nicht-einheimischer Arten, wobei nur 16,2 % der Befragten angaben, viel davon gehört zu haben und 38,4 % der Befragten angaben, noch nie davon gehört zu haben. Hinsichtlich der wahrgenommenen Wichtigkeit der einzelnen Umweltprobleme (Abbildung 9) ist zu beobachten, dass sie bis zu einem gewissen Grad mit dem Wissen über die Probleme übereinstimmt. Zum Beispiel wird das am wenigsten bekannte Problem, die Ankunft nicht-einheimischer Arten, auch als das am wenigsten wichtige Umweltproblem angesehen. Alle anderen Umweltprobleme werden von zwischen 60 % und 80 % der Befragten als „sehr wichtig" eingestuft.

- Bedeutung von kulturellen Ökosystemleistungen

Die Befragten der Umfrage wurden gebeten, die drei wichtigsten Gründe für die Wertschätzung der Umwelt der Nord- und Ostsee auszuwählen und ihrer Wichtigkeit nach zu ordnen. Die Liste der Gründe wurde entworfen, um die wichtigsten kulturellen Ökosystemleistungen (ES), die von Küstenumgebungen bereitgestellt werden, zusammenzufassen und darzustellen (Ahtiainen et al. 2019). Die beiden wichtigsten kulturellen Ökosystemleistungen, die von den Küsten der Nord- und Ostsee bereitgestellt werden, waren nach Angaben der Umfrageteilnehmer i.) die Landschaft zu genießen und ii.) die Freizeit an der Küste zu verbringen und sich zu erholen. 926 bzw. 780 Befragte nannten sie unter ihren drei wichtigsten kulturellen Ökosystemleistungen.

- Zahlungsbereitschaft

Von allen Teilnehmern, die es in die endgültige Stichprobe geschafft haben (N =1.063), gaben etwa 51 % an, dass sie generell bereit wären, etwas für das Erreichen des GES zu zahlen, 30 %

gaben an, unentschieden zu sein, während 18 % es ablehnten, einen Beitrag zu leisten. Nach der allgemeinen Screening-Frage wurde die Bereitschaft, für die Erreichung des GES in den deutschen Meeresgewässern zu zahlen, auf zwei verschiedene Arten gemessen. Erstens wurden die Befragten gebeten, eines von 18 Intervallen aus einer Zahlungskarte auszuwählen. Dies ermöglichte die Bestimmung der unteren und oberen Grenze ihrer Zahlungsbereitschaft. Die mittlere untere Grenze lag bei 33,3 EUR und die obere Grenze bei durchschnittlich 46,8 EUR. In einem zweiten Schritt wurden die Teilnehmer gebeten, in einer offenen Frage den genauen Betrag anzugeben, den sie zu zahlen bereit wären. Hier gaben die Teilnehmer im Durchschnitt eine Zahlungsbereitschaft von 34,8 EUR an.

Die Mehrheit der Personen, die nicht bereit waren, einen monetären Beitrag zur Erreichung der GES zu leisten, gab an, sich einen Beitrag schlicht nicht leisten können (29 %). Dies wurde durch die Tatsache untermauert, dass diese Befragten ein Einkommen hatten, das deutlich unter dem mittleren Einkommen der anderen Umfrageteilnehmer lag.

Von denjenigen, die einen allgemeine Zahlungsbereitschaft angaben, gaben etwa 39 % an, dass ihre Motivation in der Sorge um künftige Generationen wurzelte. Ein Drittel der Befragten führte ihr Zahlungsbereitschaft auf eine allgemeine Wertschätzung von Lebensräumen zurück, was darauf hindeutet, dass sie in erster Linie durch die Sorge um die biologische Vielfalt motiviert waren. Motivationen, die sich auf die persönliche Nutzung der Meere als Erholungsgebiet beziehen, wurden von einem deutlich geringeren Prozentsatz der Personen (13 %) geäußert.

Regressionsergebnisse

- Determinanten der Zahlungsbereitschaft

Insgesamt wurden zwei Sätze von Modellen geschätzt, um die Determinanten der Zahlungsbereitschaft zu analysieren und die mittlere Zahlungsbereitschaft sowie die Konfidenzintervalle für die aggregierte Zahlungsbereitschaft der allgemeinen Bevölkerung in Deutschland vorherzusagen. Zunächst haben wir grundlegende OLS- und Intervallregressionsmodelle zur Erklärung der Zahlungsbereitschaft implementiert. Die abhängigen Variablen dieser Modelle waren jeweils der natürliche Logarithmus (ln) von WTP_merged und WTP_interval.

Daneben wurden fortschrittliche Modellierungsansätze implementiert, um die Zahlungsbereitschaft zu erklären und vorherzusagen. Wir verwendeten ein „Double Hurdle"-Modell, das davon ausgeht, dass die Investition in ein Gut oder eine Dienstleistung – hier die Zahlungsbereitschaft zur Erreichung des GES – durch zwei verschiedene Prozesse erklärt wird: Zunächst entscheidet das Individuum, ob es überhaupt am Markt teilnimmt, d. h. ob es generell bereit ist, etwas zu bezahlen. Wenn diese Hürde überwunden ist, trifft das Individuum eine Entscheidung über die zu konsumierende Menge, d. h. wie viel es bereit ist zu zahlen (Gracia 2013, Crag 1971). Dabei ist zu beachten, dass der zweite Prozess immer noch eine Zahlungsbereitschaft von Null erklären kann (zweite Hürde). Die Aufteilung des Entscheidungsprozesses in zwei Teile ermöglicht es uns, verschiedene Variablen zur Erklärung jeder Entscheidung zu verwenden.

Insgesamt sind die meisten Effekte in den Modellen sehr ähnlich. Es lässt sich feststellen, dass die Zahlungsbereitschaft mit steigendem Einkommen, mit zunehmender Haushaltsgröße und wenn die Befragten eine höhere Bildung, d. h. einen Hochschulabschluss, erworben haben,

signifikant ansteigt. Im Gegensatz dazu sinkt die Zahlungsbereitschaft mit dem Alter der Befragten. Dieser Effekt ist jedoch nur in den Modellen mit Protestantworten signifikant. Keine signifikanten Effekte werden in Bezug auf das Geschlecht und, interessanterweise, die Entfernung zur Küste beobachtet.

Für das „Double Hurdle"-Modell stellen wir fest, dass die Wahrscheinlichkeit, am Markt teilzunehmen, d. h. eine positive Zahlungsbereitschaft zur Erreichung des GES anzugeben, umso geringer ist, je höher das Alter des Befragten ist. Im Gegensatz dazu steigt die Wahrscheinlichkeit, am Markt teilzunehmen, mit dem Wissen über die sechs in der Umfrage genannten Umweltprobleme. Hinsichtlich der Determinanten des Betrags finden wir, dass der Betrag, den die Befragten bereit sind auszugeben, um den GES zu erreichen, mit dem Einkommen steigt. Der gleiche Effekt wird für die Anzahl der im Haushalt lebenden Personen und das Wissen über die Umweltprobleme in Nord- und Ostsee beobachtet.

- Schätzungen der aggregierten Konsumentenrente

Multipliziert man die mittlere Zahlungsbereitschaft mit der gesamten erwachsenen Bevölkerung in Deutschland (69,5 Mio. Menschen am 31. Dezember 2019), so ergibt sich ein Gesamtnutzen für das Erreichen des GES in der deutschen Nord- und Ostsee bis 2040 von 3,908 Mrd EUR pro Jahr für das grundlegende Intervall-Regressionsmodell ohne Protestantworten und von 4,566 Mrd. EUR pro Jahr für das grundlegende OLS-Regressionsmodell ohne Protestantworten.

Die aus dem „Double Hurdle"-Modell geschätzte mittlere individuelle Zahlungsbereitschaft beträgt 61,6 EUR pro Person und Jahr, was zu einem mittleren Gesamtnutzen des Erreichens von GES in der deutschen Nord- und Ostsee bis 2040 führt, der sich auf 2,889 Mrd. EUR pro Jahr beläuft.

- Discrete-Choice-Experiment

Für das „Latent Class"-Modell wird die Zahlungsbereitschaft in EUR pro Jahr und Haushalt dargestellt, um den GES vollständig, d. h. um 100 % des GES im Jahr 2040, zu erreichen. Bei jedem der sechs Wahlsätze konnten die Teilnehmer zwischen einem Status quo und zwei alternativen Zuständen der Zukunft wählen. Jede Alternative setzte sich aus den sechs Umweltproblemen zusammen. Ihre Werte - 0 % (heute), 30 %, 60 % und 100 % - gaben den Anteil an, zu dem der GES im Jahr 2040 erreicht wird. Wir stellen fest, dass die Klasse 1 viel kleiner ist als die Klasse 2. Im Durchschnitt liegt die Wahrscheinlichkeit, dieser Klasse zugeordnet zu werden, bei 74 % im Vergleich zu nur 26 % für Klasse 1. Auch die Präferenzen unterscheiden sich tatsächlich zwischen den Klassen. Die Befragten in Klasse 1 sind nicht bereit, für das Erreichen des GES zu zahlen, während die Zahlungsbereitschaft für alle Attribute in Klasse 2 als signifikant und positiv geschätzt wird. Die Zahlungsbereitschaft ist für die sechs analysierten Umweltprobleme recht ähnlich und reicht von 107 EUR (Eutrophierung) bis 76 EUR (physikalische Auswirkungen).

Ergebnisse Kontrollbefragung - Zweite Welle

Eine zweite Befragungswelle wurde durchgeführt, um mögliche Auswirkungen der globalen COVID19-Pandemie auf die Zahlungsbereitschaft der Teilnehmer zu kontrollieren. Das Umfragedesign und die Methodik folgten der gleichen Logik wie bei der ersten Welle. Im Hinblick auf die Ergebnisse war die Verteilung der allgemeinen Zahlungsbereitschaft der Personen für den GES der deutschen Meeresgewässer fast identisch mit der ersten Welle.

Allerdings ist die Zahlungsbereitschaft in der zweiten Welle sowohl für die OLS- und Intervallregression, das Intervall- und das „Double Hurdle“-Modell als auch für das DCE etwas niedriger, wenn auch nicht statistisch signifikant.

1 Introduction

1.1 Background and aims of the project

Europe's coasts and marine waters, including the North Sea and the Baltic Sea, are among the most intensively exploited marine areas in the world. As is the case with most inland waters, different interests of use and conservation goals overlap in these areas. Common uses of the two seas include fishing, shipping and tourism, which are important economic activities, but also put pressure on the marine environment. Additional environmental pressures result, for example, from nutrient and litter to the Seas, pollution caused by toxic substances, and damages of the seabed. These enduring pressures continue to require protection efforts (BMU 2018a, b).

As a consequence, the Marine Strategy Framework Directive (MSFD) was adopted by the European Union (EU) in June 2008 (EU 2008). The objective of the MSFD is to achieve a "Good Environmental Status" (GES) of European marine waters. In this way, the MSFD has established for the first time a uniform regulatory framework for achieving a GES in the marine waters of the EU and thus extended EU water policy from the Water Framework Directive (WFD) to all European waters (Interwies et al. 2014). The regulatory framework of the MSFD requires the member states (MS) to develop marine strategies in close collaboration with one another. These strategies have to describe the current status as well as the target for the marine environmental status including a list of instruments and measures for achieving the GES. In concrete, the action plans of MSs have to contain an initial assessment of the current status regarding the marine environment and the expected impact of human activities. It must also be accompanied by an economic and social analysis on the use of the regarding waters and of the costs of degradation of the marine environment.

Against this background, the initial assessment of the status of the German marine waters, i.e. the German areas of the North Sea and Baltic Sea, was carried out in Germany in 2012. In the course of this, the GES was described and environmental objectives for achieving the GES were set (BMU2012a, b). The status assessment was updated in 2018, examining the relevant pressures and the status in terms of species, habitats and ecosystems. In addition, the status update reports contain information on the economic and social uses of the waters concerned. However, due to a lack of data and in contrast to some other countries, a concrete quantification of the costs of degradation of the marine environment has not yet been carried out in Germany (BMU 2018a, b).

Although the MSs committed themselves initially to reaching GES in their territorial marine waters until 2020, this goal has not been met by all countries for all environmental descriptors. The implementation report of the European Commission (EC 2020) clearly states that biodiversity loss was not halted in European marine waters during the first MSFD cycle, with some marine populations being still under threat, and that seabed habitats continue to be under significant pressure in European seas, just to name two examples. Existing management measures and joint regional programs over the last couple of decades were able to reduce selected pressures and contributed to an increase in the population size for some species, but continuing efforts are needed in the future to reach GES overall and not just for a subset of targets and descriptors. The second cycle of implementation of the MSFD thus officially started in 2018 but is experiencing delays in reporting (EC 2020a).

In the course of the next reporting cycle of the MSFD, all MS will have to prepare an updated assessment of the status of their marine waters until 2024. The aim of this project is to contribute to the German status assessment report due in 2024 by estimating the cost of degradation of the German marine environment should GES not be met. To date, there is no

harmonized approach at EU level on how to measure and assess the costs of degradation of the marine environment. However, there is a Guidance Document (EC 2018), prepared by the Common Implementation Strategy (CIS) - Working Group "POMESA", which presents different approaches to assessing the costs of marine environmental degradation. In this context, Germany follows the thematic approach, which assumes that the costs of degradation of the marine environment can be derived from the difference between the good status of the marine environment (= reference condition/GES) and the current status (= actual status). The costs of degradation are then approximated by the loss of benefits resulting from the fact that the GES has not yet been achieved (EC 2018).

Within this project, we estimate the benefits for the German population that would be generated if GES was achieved in the German marine waters, i.e., the German parts of the North Sea and the Baltic Sea. To this end, we closely follow Nieminen et al. (2019) and Nordzell et al. (2020) and derive the willingness-to-pay (WTP) of the German population for reaching a GES in the German marine environment using the contingent valuation method (CVM). This information is used to approximate the annual cost of degradation of the marine environment, which would arise if GES was not reached for the German marine waters. Notably, the contingent valuation scenario presented to the respondents covers all descriptors mentioned in the MSFD and both Seas that belong to German territory. The close alignment of the project's approach with the procedure implemented in Finland (Nieminen et al. 2019) and Sweden (Nordzell et al. 2020) enables a direct comparison of the results for Germany with the Finnish and Swedish findings in order to form a basis for European-wide policy making.

1.2 Related literature

Over the past 25 years, efforts have been made to quantify the benefits of an improved status of the marine environment in Europe with a particular effort having been undertaken in the Scandinavian countries. A number of primary and secondary studies have therefore already been conducted for the Baltic Sea, using various methods to assess the WTP of the population for an improved environmental status of coastal and marine waters, often as part of large-scale research projects. The North Sea has in this respect been studied much less extensively and the regional focus of primary valuation studies pertaining to the North Sea is in the United Kingdom (UK) and Ireland. Extensive reviews of existing primary studies and the methods, results and limitations pertaining to these studies can be found in Bertram and Rehdanz (2013) for all European waters and in Sagebiel et al (2016) for the Baltic Sea.

The most integrative and comprehensive research endeavor including an economic valuation of the ecosystem services (ES) provided by the Baltic Sea started in the year 2009. Under Swedish leadership, research institutions from all nine countries bordering the Baltic Sea joined forces to identify pressures in the Baltic Sea region and possible measures to achieve good ecological status and the associated costs and benefits. Within this framework, the largest coordinated valuation study in the Baltic Sea region to date estimated the WTP for a reduction of eutrophication in the Baltic Sea for all nine countries using CVM (Ahtiainen et al. 2014). Czajkowski et al (2015b) use the data from the same study to determine the recreational benefits of the Baltic Sea for all riparian countries using the travel cost method (TCM).

It can be observed that mostly stated preference methods, i.e., contingent valuation (CVM) and discrete choice experiments (DCE), have been used to elicit economic benefits of improved marine environmental conditions. Stated preference methods use hypothetical scenarios for environmental changes to elicit the WTP of survey respondents. They are quite flexible and in principle the only methods that are able to capture non-use values in addition to use values. In the context of the Baltic Sea, Kosenius and Ollikainen (2015) estimate the WTP of Finnish,

Swedish and Lithuanian populations for improvements in the marine environment using a DCE with the attributes healthy perennial vegetation, protection of currently pristine areas, and size of fish stocks. Kosenius (2010) examines the WTP of Finnish citizens for higher water quality in Finnish coastal waters also using a DCE. For the Estonian part of the Baltic Sea, Karlõševa et al. (2016) investigate the preferences of Estonian households regarding the choice of offshore locations for wind farms or the establishment of marine protected areas using a DCE. Further, Tuhkanen et al. (2016) use a DCE to investigate how Estonians value the reduction of water pollution from oil and chemicals in order to obtain better water quality for recreational purposes. Pakalniete et al. (2017) provide another application of a DCE to estimate the benefits of reaching GES in the Latvian marine waters of the Baltic Sea. The most recent examples of primary studies using the CVM in the context of the Baltic Sea are Nordzell et al. (2020), Nieminen et al (2019), and Ahtiainen et al. (2014) mentioned above.

Studies eliciting the economic benefits of improvements in marine environmental conditions in the North Sea area are less abundant than studies for the Baltic Sea and have mostly been carried out in the UK or Ireland. For Ireland, Norton and Hynes (2014) estimated the value of achieving GES using a DCE and describing the valuation scenario with five environmental attributes, including biolocical diversity and healthy marine ecosystem, sustainable fisheries, pollution levels, non-native species, and physical impacts. Hynes et al. (2013) use a DCE to elicit the benefits of reaching the targets of the EU Bathing Water Directive in Ireland's coastal waters. Börger et al. (2014) investigate the applicability of a DCE to value the expected benefits arising from the conservation of an offshore sandbank in UK waters. Older studies referring to other regions of the North Sea are Longo et al. (2007) who use a DCE to value water quality changes in Belgium and Le Goffe et al. (1995) who use CVM to value water quality changes in France (for more details, see Bertram & Rehdanz 2013).

Besides studies using stated preference methods, also revealed preference methods and hybrid methods combining revealed and stated behavior have been used for valuing water quality changes in the Baltic Sea. In the context of coastal and marine waters, revealed preference studies mostly focus on estimating recreational benefits arising from improving environmental conditions. These studies thus only capture use values in their benefit estimates and no non-use values. The revealed preference method used most often to estimate recreational benefits of changes in marine environmental conditions is the TCM used, e.g., by Czajkowski et al. (2015a, see above) and Vesterinen et al. (2010). In addition, also the contingent behavior method (CBM) has been used to estimate recreational benefits. This method combines data on past trips with hypothetical data on potential future trips under changing environmental scenarios. Bertram et al. (2020), for example, estimate welfare changes from changing conditions of the coastal environment for Germany, Finland, and Latvia. Lankia et al. (2019) uses CBM to examine the effects of changes in water quality on recreational benefits, focusing on swimming trips in Finland. Hanley et al. (2003) estimate the benefits of reaching targets of the EU Bathing Waters Directive for a coastal area in Scotland also using CBM.

1.3 Contribution of the project

Based on the literature review presented in section 1.2, it can be observed that welfare estimates for changes in environmental quality in German waters based on original, primary studies is rather limited. The only welfare estimates directly available for Germany can be taken from Ahtianinen et al (2014), Czajkwoski et al. (2015), and Bertram et al. (2020). However, all three studies only cover the German area of the Baltic Sea and none of them covers the German area of the North Sea. In addition, Ahtiainen et al. (2014) only consider the effects of eutrophication and not the other descriptors covered by the MSFD and they consider a different

policy target, i.e., reaching the goals of the Baltic Sea Action Plan. Moreover, Czajkowski et al (2015a) and Bertram et al. (2020) only encompass use values, i.e., recreational benefits generated by the Baltic Sea, and do not include non-use values. The existing studies are thus only of limited use for the implementation process of the MSFD in Germany.

The contribution of this project is to close the identified research gaps. We include all descriptors covered by the MSFD in our analysis and we consider the German parts of the North Sea in addition to the German parts of the Baltic Sea. Moreover, a stated preference method, namely CVM, is used to capture non-use values as well as use values with the benefit estimates. Thus we derive individual and aggregate benefit estimates for reaching GES by 2040. In addition, this report further presents results of a DCE. This technique is used to not only estimate the WTP to achieve GES as a whole, but also to quantify the marginal WTP for reaching GES with respect to individual MSFD descriptors such as eutrophication or biodiversity.

Thus, the project outcomes will be used in various ways for the MSFD-implementation as well as for the political process accompanying it:

- Regarding the MSFD-implementation in Germany and reporting according to the requirements of the Directive, the results will be used for the German status assessment report due in 2024 by estimating the cost of degradation of the German marine environment should GES not be met (Art.8-reporting). To this aim, the setup of the study and intermediate results have been shared with and discussed at the relevant working group of the BLANO ("Bund/Länder-Ausschuss Nord- und Ostsee"; the cooperation forum responsible for MSFD-implementation in German), that is the working group "socioeconomics" (Fach-AG Sozioökonomie).

- Regarding regional cooperation at HELCOM-level, the results of this study will be presented and discussed at the HELCOM Economic and Social Analyses (ESA) network in order to advance the understanding of the costs of degradation and approaches for estimating these. In addition, and if available in time, the study results will be integrated into the BSAP ("Baltic Sea Action Plan") update. Finally, the next phase of the HELCOM "Holistic Assessment of the Ecosystem Health of the Baltic Sea" (HOLAS III) will integrate the study results.

- At EU-level, the project results will be presented and discussed at the CIS-working group POMESA ("Programme of Measures and Economic and Social Analysis" working group, Common Implementation Strategy), providing a better understanding of the possibilities and challenges for estimating the CoD.

- Finally, the German authorities can utilize the specific WTP-results of this work in order to support additional financing for the German PoMs, since the values established show the willingness for a faster and comprehensive implementation of MSFD-measures.

2 Valuation method, survey design and implementation

2.1 Valuation method

The aim of the project was to assess the total economic benefit of reaching GES in the German marine waters as defined by the MSFD. Since it was the aim to cover use values as well as non-use values with the benefit estimates, a stated preference method was chosen. Former research has shown that a considerable part of the total economic benefit of changes in the marine environment is rooted in non-use values (Ahtiainen et al. 2014). Consequently, using a stated preference method results in more comprehensive benefit estimates and increases the policy-relevance of the derived results. In addition, the comparability of the study results with estimates from Finland and Sweden was another key aim of the project. Consequently, the first main parts of the survey were designed to resemble as closely as possible the example of Nieminen et al. (2019) comprising a contingent valuation scenario for deriving the benefit estimates of reaching GES. Using CVM allows deriving individual WTP estimates for reaching GES for the whole bundle of environmental descriptors presented to the respondents. In a second step, the individual estimates were then scaled up to the whole German population.

In addition to the CVM, a CE was included in the survey and positioned after the CVM scenario and follow-up questions. The reasons for including a CE were twofold. Firstly, the CVM allows valuing changes in a comprehensive bundle of attributes, but only for one fixed scenario and not for individual level changes among attributes. Since there was a policy interest to also get an understanding of the relative importance of the different descriptors, the DCE was included in addition to the CVM. Secondly, the benefit estimates resulting from the CVM should be validated by means of including the DCE.

2.2 Survey design and data collection

The survey was designed following the example provided by Nieminen et al. (2019), but was adapted to match German circumstances. In the first place, we had to account for the fact that German marine waters comprised the North Sea in addition to the Baltic Sea, which induced rephrasing of several questions and adding questions, e.g., on the relative importance of the North Sea and the Baltic Sea to the respondents. Secondly, respondents in Germany live on average further away from the coast. Consequently, reasons to visit the coast are more often single holiday trips rather than day-to-day recreational activities (Bertram et al. 2020), which is reflected in deleting selected questions on recreational activities. Moreover, questions on concerns about environmental problems in the German marine waters dropped in order not to influence the respondents' preferences towards larger WTP for environmental improvements.

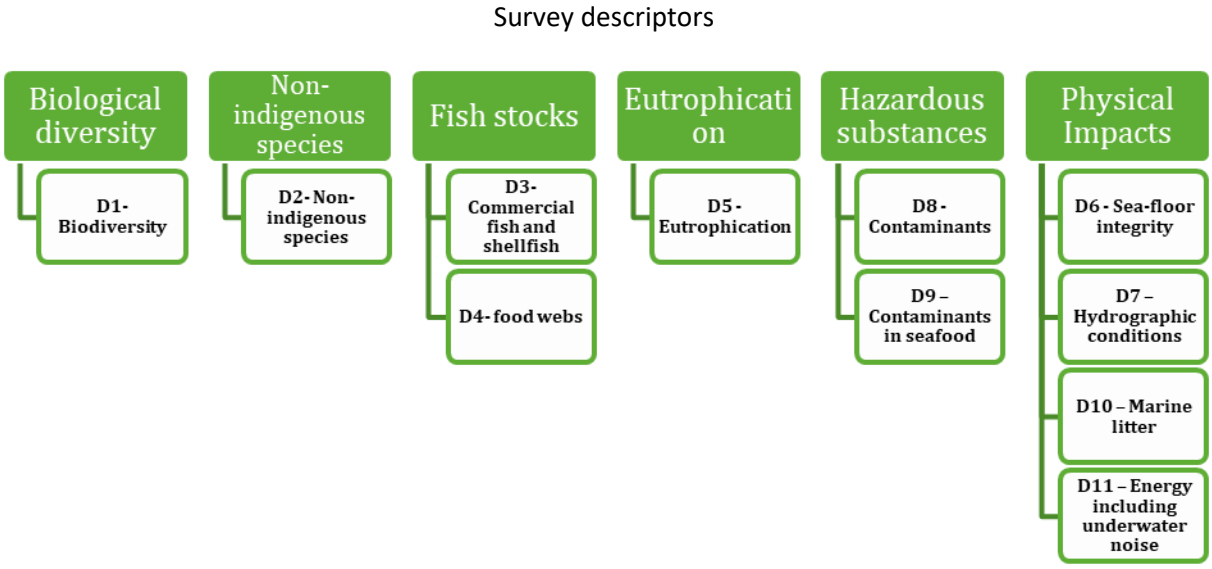
The adaptation of the survey to German circumstances took part in close cooperation with experts from several divisions of the UBA, including economists and natural scientists, and comprised several feedback loops. Feedback on selected parts of the questionnaire was also gathered in four focus group discussions comprising up to 12 participants randomly drawn from the general public. Focus group discussions took place in Hanover, Bremen, Leipzig and Kiel in November 2019. The questionnaire was adapted afterwards and discussed again at an interdisciplinary expert workshop in January 2020 in Berlin. After programming, the online version of the survey was thoroughly pre-tested by researchers and lay people before actual implementation. A soft-launch with 25 participants furthermore ensured that the survey was running smoothly.

The survey consisted of five parts. In the initial part of the survey, respondents were asked about their previous use of and general relationship to the North Sea and Baltic Sea. This

included questions on the distance from their home to the coast, frequency of visits, activities carried out, place of last visit, positive and negative experiences, sites that could be used as substitutes for spending time at the German marine waters, plans for future visits, and importance of a range of cultural ES. Given the complex nature of the valuation task to follow, this part of the survey was designed to familiarize respondents with the topic and gather general data regarding leisure behavior pertaining to the German coasts.

In the second part of the survey, the current status of the German marine waters was presented to the respondents. Due to the large complexity of the environmental issues, the eleven descriptors presented in the MSFD were grouped into six environmental problems following Nieminen et al. (2019) (see Figure Figure 1 Descriptors used in the survey and original descriptors according to the MSFD) which were described briefly but comprehensively to the respondents. The six environmental problems described were eutrophication, decline in biodiversity, introduction of non-indigenous species, decline in fish stocks, introduction of hazardous substances, and physical impacts and waste. The environmental problems were shown in random order to the respondents. After each short presentation, the respondents were asked how familiar they had been with the respective environmental problem before taking the survey.

Figure 1 Descriptors used in the survey and original descriptors according to the MSFD



Source: Own presentation based on Nieminen et al. (2019)

In the third part of the survey, the valuation scenario was presented to the respondents. This included a brief description of the political background, the aim of reaching GES and the need to finance measures to reach GES, which was followed by the general question if respondents were in principal willing to pay to reach GES in the German marine waters or not. The payment vehicle used was an annual individual fee pertaining to each adult individual in Germany, which would have to be paid from 2021 until 2040. Respondents who were generally willing to pay to reach GES were directed to a detailed summary of the current status of the German marine waters in direct comparison to the GES (Table 1). Respondents were then asked for their WTP using a payment card approach followed by the possibility to give a single value within the chosen ranges. This procedure follows Rowe et al. (1996) and was also implemented by Nieminen et al. (2019).

The valuation scenario was followed by questions on reasons for being willing or not being willing to pay, the relative importance of the environmental problems, security about the amount of WTP, consequentiality of the valuation question, and understanding of the task.

Table 1 Description of current status and GES of the German marine waters

	Current status	Aim: Good environmental status
Excess nutrient enrichment	Strong algal growth Baltic Sea: Turbid water North Sea: Algae foam on the beach	Low algal growth Baltic Sea: Clear water North Sea: No algae foam on the beach
Biolocical diversity	Decreasing diversity of typical habitats and species	Stable large diversity of typical habitats and species
Non-indigenous species	Continuous introduction	No further introduction
Fish stocks	Some fish stocks in poor condition Unbalanced size and age distribution	All fish stocks are in good condition Balanced size and age distribution
Hazardous substances	Exceeding threshold values for some substances	All threshold values are met
Physical impacts and litter	Severe impairment of habitats, animals and plants through noise, damage to the seabed, cooling water and waste	No impairment of habitats, animals and plants through noise, damage to the seabed, cooling water and waste

Source: Own presentation

The fourth part of the survey consisted of the presentation of the DCE. We briefly introduced the DCE to the respondents by highlighting the possibility that GES would not be reached uniformly across all environmental problems. The options of the DCE were designed such that different environmental problems could be reached to different extents. These extents were described quantitatively using percentages as suggested in recent studies on the state-of-the-art in contingent valuation (Johnston et al. 2017). Possible levels were “0% (as today)”, “30% reached”, “60% reached”, and “100% reached (GES fully achieved)”. The attributes used in the DCE were equal to those used in the CVM except that physical impacts and litter were separated into two attributes. Each respondent received six independent choice sets. An example of a choice set presented to respondents is given in Table 2.

Table 2 Example of a choice set

	Status A	Status B	Status C
No eutrophication	30% reached	60% reached	Good environmental status is not achieved Status 0% (as today)
Stable biological diversity	60% reached	0% reached	
No non-indigenous species	0% reached	100% reached	
Good fish stocks	0% reached	0% reached	
Hazardous substances negligible	30% reached	0% reached	
Physical impacts low	0% reached	0% reached	
Litter without impact	30% reached	100% reached	
Annual fee	350 EUR	8 EUR	0 EUR

Source: Own presentation

In the final part of the survey respondents were asked to provide general information about their socio-demographic background and environmental attitudes. In addition, we added questions on the anticipated effects of the COVID-19 pandemic on the respondents.

The survey was implemented in to waves. The first wave (main survey) was implemented in March and April 2020. Norstat offers a high-quality online panel characterized, e.g., by offline recruiting and a low frequency of invitations to surveys for the single respondents. To ensure a representative sample, quota regarding gender, age, education and the 16 federal states were imposed. In total, 1,084 interviews were completed. In the course of the data cleaning process, six respondents had to be removed from the data set because they provided incomplete or inconsistent information regarding their postal code. In addition, 14 respondents had to be removed due to implausible high levels of net household income and one due to unreasonable high levels of WTP and speeding. Thus, the final sample consists of 1,063 valid respondents. The average survey participant took 18 minutes to answer all survey questions.

The second wave (control survey) was conducted in September 2020. Besides some additional control questions, the same questionnaire of the first wave was used. The main objective of implementing a second wave was to investigate whether the COVID19-pandamic influenced survey results. A total of 881 people participated in the questionnaire of which 863 ended up in the final sample after data cleaning. The average respondent needed 20 minutes to answer the questionnaire. The following table shows that the means for the explanatory variables vary only marginally.

Table 3 Comparison of descriptive statistics of model variables for both survey waves

Variable	Variable description	Mean	Std. dev.	Min	Max	N
Income Wave 1	Monthly net household income (EUR)	2587.1	1230.3	440	10000	1063
Income Wave 2	Monthly net household income (EUR)	2696	1296.5	450	10000	863
Age Wave 1	Age (years)	49.6	16.4	18	86	1063
Age Wave 2	Age (years)	49.7	16.3	18	87	863
Female Wave 1	1 if respondent is female, 0 else	0.51	0.5	0.0	1.0	1063
Female Wave 2	1 if respondent is female, 0 else	0.52	0.499	0.0	1.0	863
High education (%) Wave 1	1 if respondent has high education (university degree), 0 else	0.21	0.4	0.0	1.0	1063
High education (%) Wave 2	1 if respondent has high education (university degree), 0 else	0.22	0.41	0.0	1.0	863
Household size Wave 1	Number of people living in respondent's household	2.3	1.17	1.0	10.0	1063
Household size Wave 2	Number of people living in respondent's household	2.2	1.19	1.0	8.0	863
Minors in household wave 1	Number of minors living in respondent's household	0.3	0.7	0.0	6.0	1050
Minors in household wave 2	Number of minors living in respondent's household	0.35	0.78	0.0	5.0	852

Source: Own data and presentation.

3 Econometric approach

3.1 Contingent valuation

The analysis of the contingent valuation was performed by using three different steps of data analysis. In total three different models were calculated based on different subsets of the sampled data. The first two models are exact replications of the basic models presented by Nieminen et al. (2019). One of the basic models was calculated by using ordinary least square estimation to model the stated WTP given by participants in the open ended question. The second basic model is a Tobit Model used to predict the intervals chosen by survey participants. Both these models excluded all participants identified as protest respondents[1] as defined by Nieminen et al. (2019).

Departing from the Finnish study and due to the low explanatory power of these basic models, a different statistical approach was taken for an extended analysis of Germans' WTP. After thorough analysis of the alternatives a Double Hurdle Model was selected. This model is apt to deal with non-normally distributed error terms and a spike in zeros. The approach assumes that decisions about WTP consist of two separate steps. During the first step participants assess whether they are willing to invest in a certain good at all while the separate, second thought process determines the amount they are willing to pay for a good or service (Garcia 2013, Cragg 1971). When applied to samples with a spike in zero observations, the advantage of this approach is that it allows for zeros to be generated by either of these processes. As such, the model can accommodate people who would in theory be interested in contributing to achieving the good environmental status of the German marine waters, but who report a WTP of zero due to other factors such as low income.

3.2 Choice experiment

The starting point for the analysis of the choice data is the random utility model (RUM) (McFadden's 1974). The underlying assumption is that the researcher does not have complete information with regard the individual decision maker *n* (Ladenburg et al., 2020). Accordingly, individual preferences are made up of a systematic (V) and a random (ε) component

$$U_{ni} = V_{ni}(x_{ni}\beta) + \varepsilon_{ni} \text{ with} \qquad (1)$$

U_{ni} is the true utility associated with alternative *i* out of a set of available alternatives *j* that cannot be observed, V_{ni} is the deterministic part and a function of the attributes (x_{ni}) and ε_{ni} the unknown part that is treated as random. β represents a vector of coefficients that reflects the desirability of the attributes. An individual choosing one alternative over another implies that the utility (U_{ni}) of that alternative is greater than the utility of the other alternatives. It is assumed that the error components are independently and identically distributed (IID) according to a type 1 extreme value distribution, which yields the conditional logit (CL) model where the probability of individual *n* choosing alternative *i* is (Ladenburg et al., 2020)

$$P_{ni} = \frac{\exp(\mu V_{ni})}{\sum_{j \in C} \exp(\mu' V_{nj})} \qquad (2)$$

[1] Following the definition of Nieminen et al. (2019), the subsequent stated reasons for unwillingness to pay were considered to be protest answers "I am unwilling to pay because I do not believe that it is possible to achieve a good status", "I think that those who pollute should pay more", "I do not want to pay any extra tax" and "I do not believe the money will be used for the purpose". All other participants who gave different reasons for their unwillingness to pay were assumed to have a true zero WTP.

The scale parameter μ is usually normalised to 1 in practical applications for any one data set as it can only be identified together with the vector of parameters (Ladenburg et al., 2020). As the CL assumes that all individuals have the same preferences, we additionally apply a latent class (LC) model (Hess 2014). It allows to capture unobserved heterogeneity in taste sensitivities. To accommodate this, the LC model assumes the existence of a finite number of a priori unknown segments *s* in a population, each one of which has different values for the vector of taste coefficients (β_s). Using a probabilistic class allocation model, every individual is assumed to belong to each of the classes in the model with a certain probability $\boldsymbol{\pi}_s$. This probability lies between 0 and 1 and sums to 1 across all classes. Employing the LC model requires the external specification of the number of classes. A common procedure is to sequentially estimate models with an increasing number of classes s (s = 1, 2, 3, 4, …, S) and to select the number of classes using, among other things, information criteria such as the Bayesian Information Criteria (BIC).

For this study we estimate the LC model in the so called WTP space. Instead of calculation marginal willingness to pay (WTP) estimates by dividing the segment specific betas ((β_s) for the non-monetary attributes through the segment specific beta of the monetary attribute, in this case the ratio of the two coefficients is directly estimated in the model. This way, the model output directly gives the WTP estimates and their statistical significance.

4 Results main survey - First wave

4.1 Descriptive statistics

4.1.1 Socio-demographic characteristics of the sample

Table 4 reports the central tendencies of the socio-demographic data collected from survey respondents. The average respondent has a net monthly household income of 2,587 EUR. The standard deviation was quite high (1,230 EUR) showing that income varies greatly across the sample. The same is true for the participants' age, which ranges between 18 and 86 years, and averaged 49.6 years. Furthermore, the sample consists of slightly more women than men (51.2 percent) and about 21.1 percent of all participants have undergone higher education, meaning that they had obtained a university degree. With regard to household size, the average household consists of 2.3 people with 0.3 being minors. In order to calculate the income for individuals, rather than households, the OECD- scale[2] was used.

Table 4 Descriptive statistics of sociodemographic information about survey participants

Variable	Variable description	Mean	Std. dev.	Min	Max	N
Income	Monthly net household income (EUR)	2587.1	1230.3	440	10000.0	1063
Equalized Income	Equalized income according to OECD equivalence scale(EUR)	1711	772.9	200	8500.0	1063
Age	Age (years)	49.6	16.4	18	86	1063
Female	1 if respondent is female, 0 else	51.2	0.5	0.0	1.0	1063
High education (%)	1 if respondent has high education (university degree), 0 else	21.1	0.4	0.0	1.0	1063
Household size	Number of people living in respondent's household	2.25	1.17	1.0	10.0	1063
Minors in household	Number of minors living in respondent's household	0.3	0.7	0.0	6.0	1050

Source: Own data and presentation.

In the following we present how the socio-demographic characteristics of the survey respondents relate to the socio-demographic profile of the general public in Germany (Target population, see Table 5). Note that the sample population with N =1,063 contains all valid survey responses. The sample population is on average four years older than the target population. In addition, it has a larger monthly net household income and slightly higher education levels, which is quite common in internet surveys (Lindhjem and Navrud 2011) and has also been observed in related studies (Bertram et al. 2020). We also report the socio-demographic characteristics of the sub-samples contained in the various econometric models presented below (sections 4.2.1.1, 4.2.1.2, and 4.2.3).

[2] https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Soziales/Sozialberichterstattung/Glossar/oecd-skala.html

Table 5 Comparison of sample population and target population

Variable	Sample population	Basic models sample (OLS and interval regression)	Double hurdle sample	Target population
Age (years)	49.6	49.01	49.58	45.7[a]
Female (%)	51.2	51.7	48	50.7[b]
Household size	2.3	2.27	2.29	2.0[c]
Minors per household	0.3	0.3	0.3	0.3[b,c]
High education (%)	21.1	21.6	22.5	18.0[d]
Income (EUR)	2587.1	2588	2665	2079.0[e]
Sample Size (N)	1063 f	782	850	83 Mio.[g]

Sources: a UN DESA: „World Population Prospects 2019 Revision". 2019, b DESTATIS: „Datenreport 2018", Kapitel 1: Bevölkerung und Demografie. 2018; c DESTATIS: „Bevölkerung und Erwerbstätigkeit, Haushalte und Familien - Ergebnisse des Mikrozensus". 2018.; d DESTATIS: „Bildungsstand der Bevölkerung, Ergebnisse des Mikrozensus 2018". S.22, 2019.; e DESTATIS: „Volkswirtschaftliche Gesamtrechnungen, Inlandsproduktberechnung Vierteljahresergebnisse". S.11, 2019. And own data and presentation; f this applies for all variables except "Minors per Household" which was only answered by 1050 participants; g DESTATIS "Bevölkerung nach Altersgruppen Deutschland" Retrieved from https://www.destatis.de

4.1.2 Travel behaviour, knowledge about environmental problems, and importance of cultural ecosystem services

4.1.2.1 Distance analysis

The distance between the place of residence of the respondent and the closest coastal town to either the North or Baltic Sea from a set of self-reported destinations (see section 4.1.2.2) was calculated using the postal codes provided by the participants. The mean was measured to be 296.3 km with a standard deviation of 171.5 km. The maximum distance was 687.3 km.

Table 6 Distance to the sea

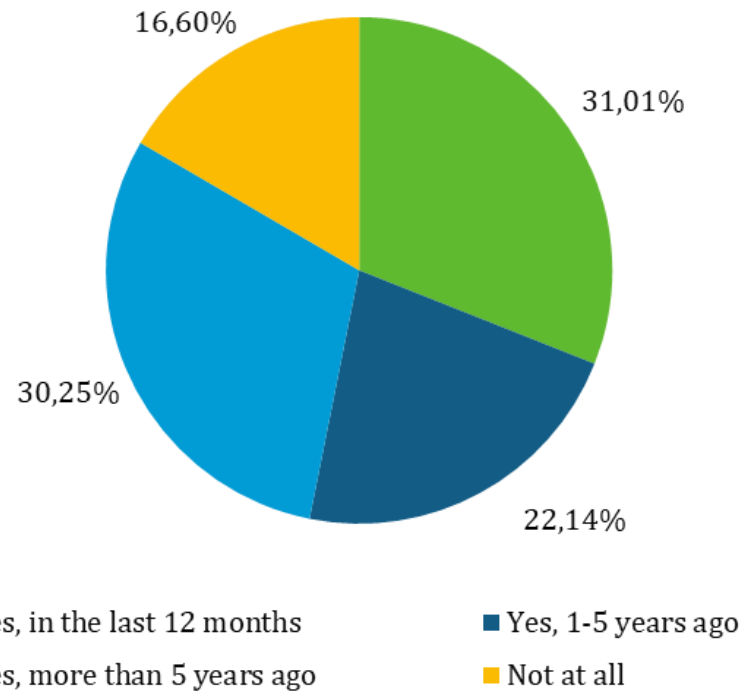
Variable	Variable description	Mean	SD	Min.	Max.	N
Distance to the Sea	Distance to the closest town at either North or Baltic Sea based on the postal code provided by respondents	296.3	175.1	0.8	687.3	1063

Source: Own data and presentation

4.1.2.2 Travel behaviour

In order to analyze their travel behavior respondents were asked whether and when they had last spent leisure time at the North Sea or the Baltic Sea coasts (Figure 2). The majority of the respondents had been at the German coasts at least once during the last five years (53.2 percent). Roughly one third (30.3 percent) of the respondents stated that they had been there more than five years ago, and the remaining 16.6 percent stated that they had never visited the German coasts for spending leisure time there. In total, the overwhelming majority (83%) had been to the German marine waters.

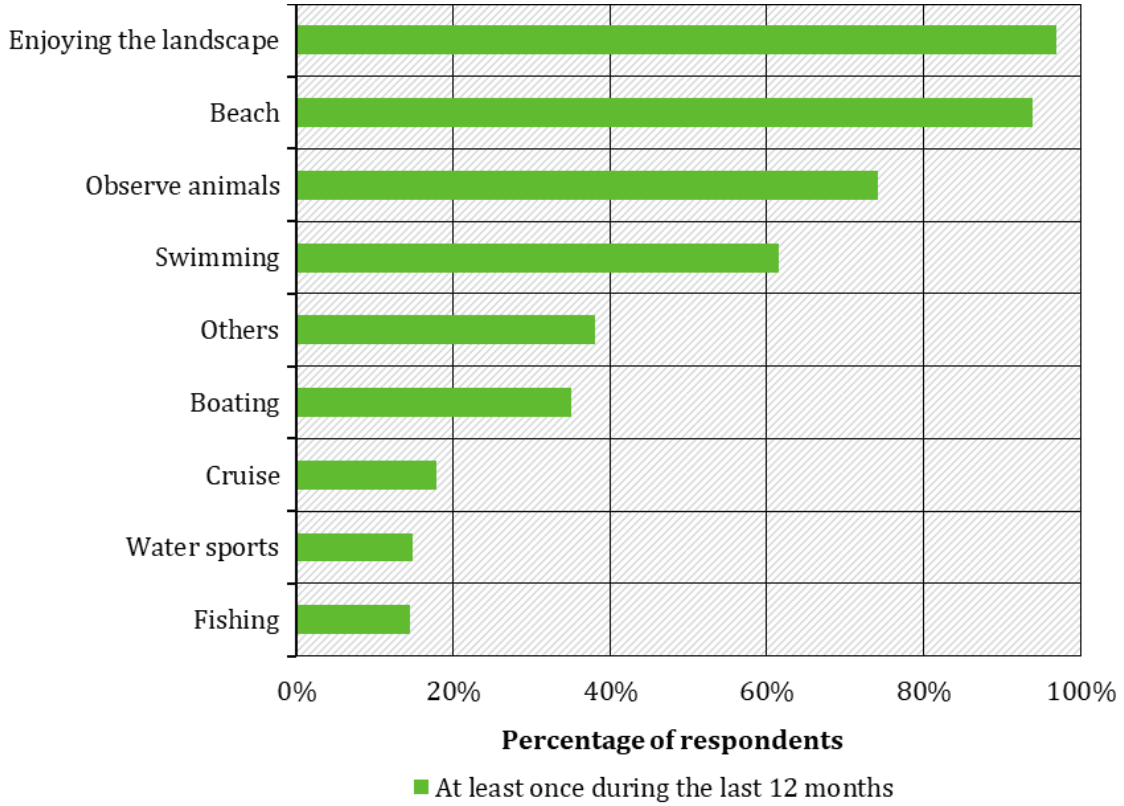
Figure 2 Travel frequency to the German coasts for leisure activities



Source: Own data and presentation.

Respondents who had visited the German coast a tleast once during the last 12 months (N=325) were subsequently asekd which activities they had carried out during their stay (Figure 3). Almost all respondents (96.9 percent) responded that they had visited the coast for enjoying nature and the landscape. The second most often mentioned activity was spending time at the beach (including sunbathing, walking, running and cycling at the beach), which was mentioned by 93.8 percent of the respondents. Other important activities were observing animals (carried out by 74.2 percent), swimming (61.5 percent), and boating (35.1 percent). Less important activities were being on a cruise, other water sports, and fishing, which were all carried out by less than 20 percent of the respondents.

Figure 3 Activities carried out at the coast during the last 12 months



Source: Own data and presentation.

Respondents who indicated that they had visited the German marine waters at least once in the past (N=874) were then directed to a set of questions asking more details about their last trip to the German coast. Firstly, these respondents were asked whether they had last spent leisure time at the North Sea or at the Baltic Sea. 405 respondents (46.3 percent) indicated that they had last visited the North Sea and 459 respondents (52.5 percent) indicated that they had last visited the Baltic Sea for leisure purposes; the rest did not remember. Regarding the name of the location, 670 respondents were willing to give a free text answer on the name of the location, which they had last visited. Of these, 664 answers could be sensibly analyzed, but only 628 answers were actually locations at the German coast of the North Sea or the Baltic Sea. In total, the survey respondents mentioned almost 190 different destinations. After a thorough validity check and clustering the towns and villages located on the German islands, still more than 160 different locations remained. For the Baltic Sea, the three most often indicated travel destination visited were the island Rügen (57 times mentioned) followed by Warnemünde 22 times mentioned), and Fehmarn (19 times mentioned). Regarding the North Sea, the three most often indicated travel destinations were Sylt (23 times mentioned), Sankt Peter-Ording (22 times mentioned), and Cuxhaven (21 times mentioned). The most popular locations were quite balanced regarding the location at either the North or the Baltic Sea. See Table 7 for an overview of the top ten travel destinations.

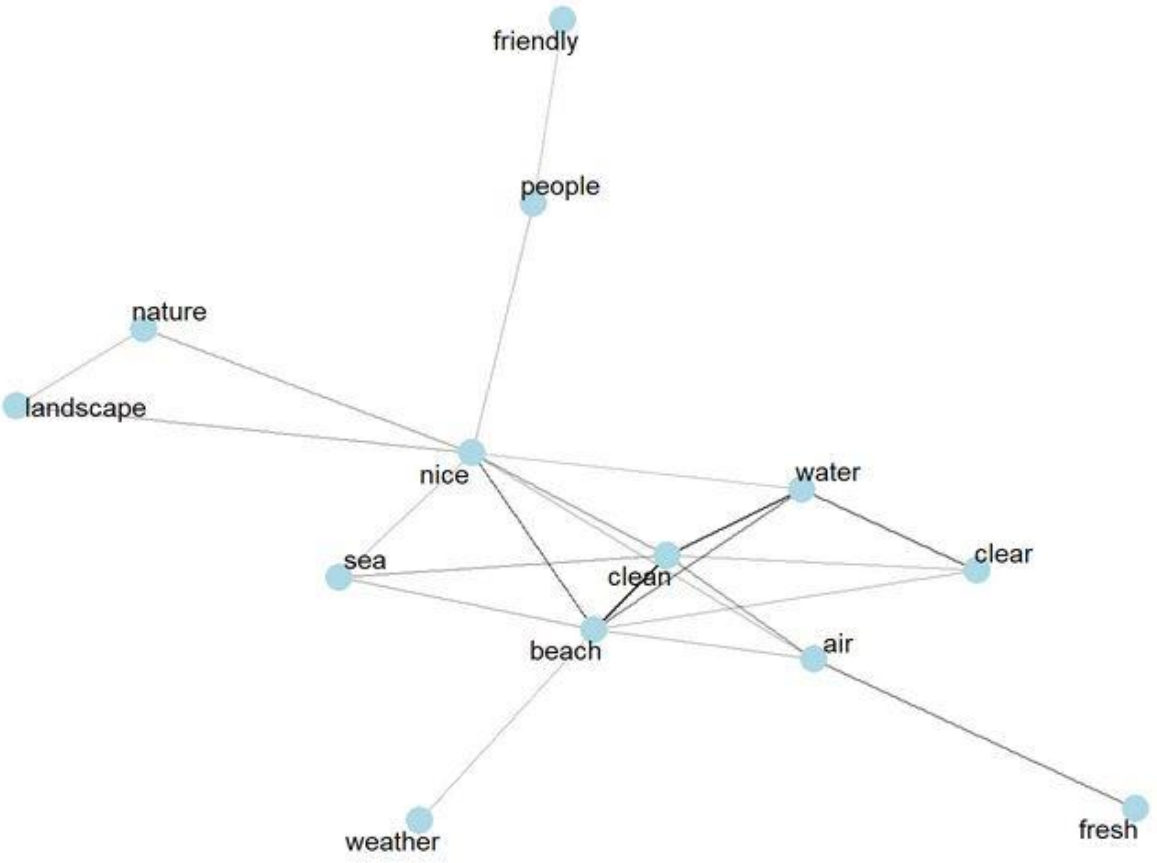
Table 7 Top ten travel destinations at the North and Baltic Sea

Location	Number of respondents	Sea
Rügen	57	Baltic Sea
Sylt	23	North Sea
Sankt Peter-Ording	22	North Sea
Warnemünde	22	Baltic Sea
Cuxhaven	21	North Sea
Fehmarn	19	Baltic Sea
Norderney	17	North Sea
Travemünde	17	Baltic Sea
Büsum	14	North Sea
Norddeich	14	North Sea

Source: Own data and presentation.

Respondents were then given the possibility to report freely on any positive and negative experiences they had encountered during their last stay at the coast. The words most frequently used to describe positive memories were “clean”, “beach”, “water” and “nice”. The visualization network in Figure 4 below depicts the positive associations people had with the sea. Depending on how often words were mentioned together, the lines connecting them are thicker and darker.

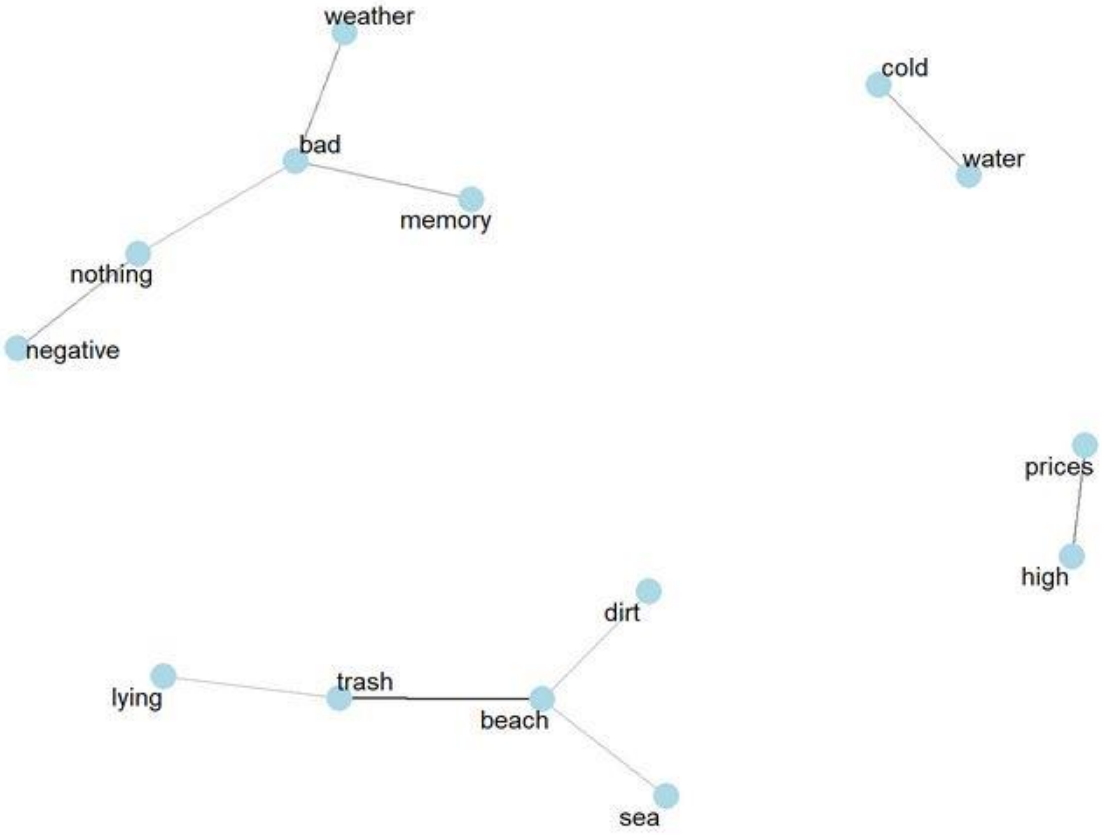
Figure 4 Visualization network for positive memories



Source: Own data and presentation.

Similarly, a set of qualitative analyses was performed on the negative memories reported by the survey participants. Here, the most frequent word were “beach”, trash”, “prices” and “high”. Figure 5 shows the visualization networks for negative memories.

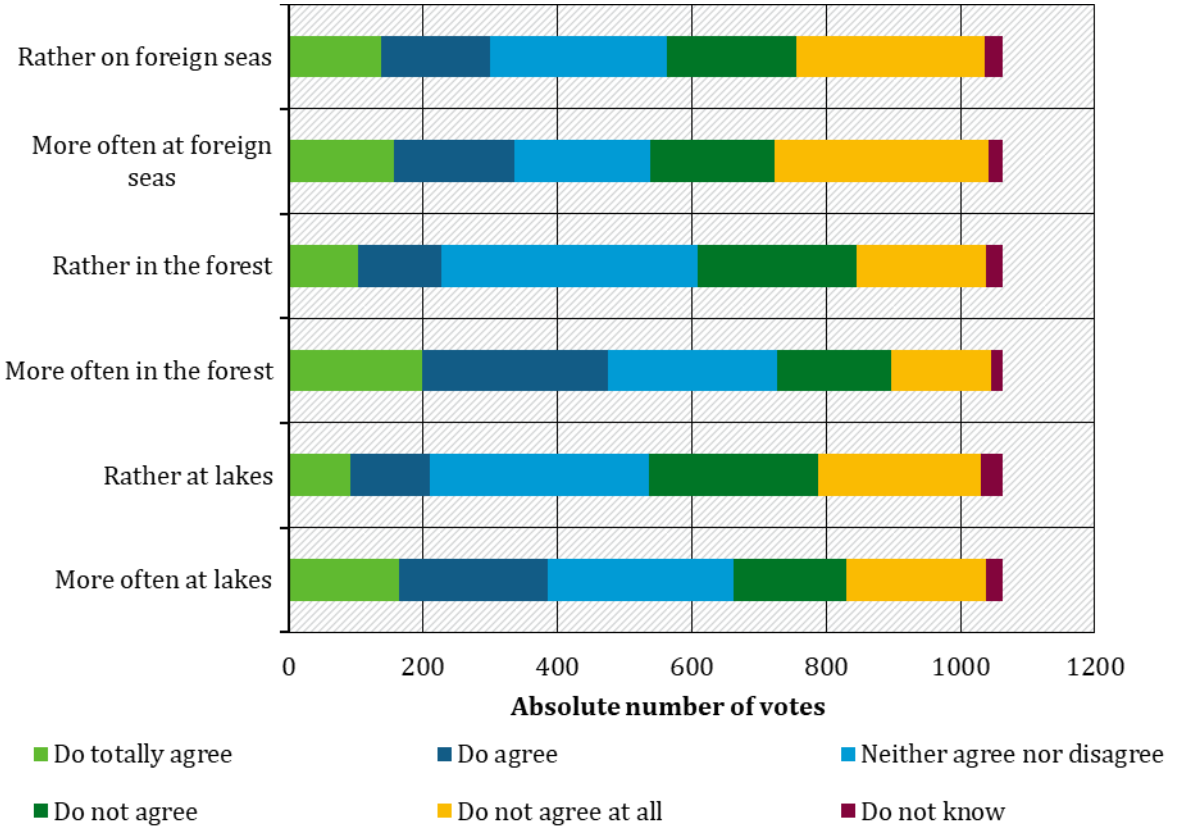
Figure 5 Visualization network for negative memories



Source: Own data and presentation.

Furthermore, all respondents were asked to state their preferences on different travel destinations which can be considered substitutes to spending time at the German coasts. Figure 6 illustrates that the majority of the respondents would rather spend time at the German coast compared to all three alternatives mentioned (foreign seas, forest, and lakes). Only 28.2 percent of the respondents agree or totally agree that they would rather spend time at foreign seas, 21.4 percent of the respondents would rather spend time at forests, and 19.8 percent of the respondents would rather spend time at lakes. However, stated behaviour diverges from the stated preferences of the respondents. In particular, for the case of forests and lakes considerably more respondents state that they spend more time in forests and at lakes than actually prefer to do so. The most plausible reason for this is that most people in Germany live quite far away from the two Seas such that a stay at the coast is more suited for a one-time holiday than for day-to-day leisure activities. This would also explain why the shares of stated behaviour and stated preferences are closer together for foreign seas. These stays are equally suited for one-time holidays and are thus closer substitutes for stays at the German coast of the North or Baltic Sea.

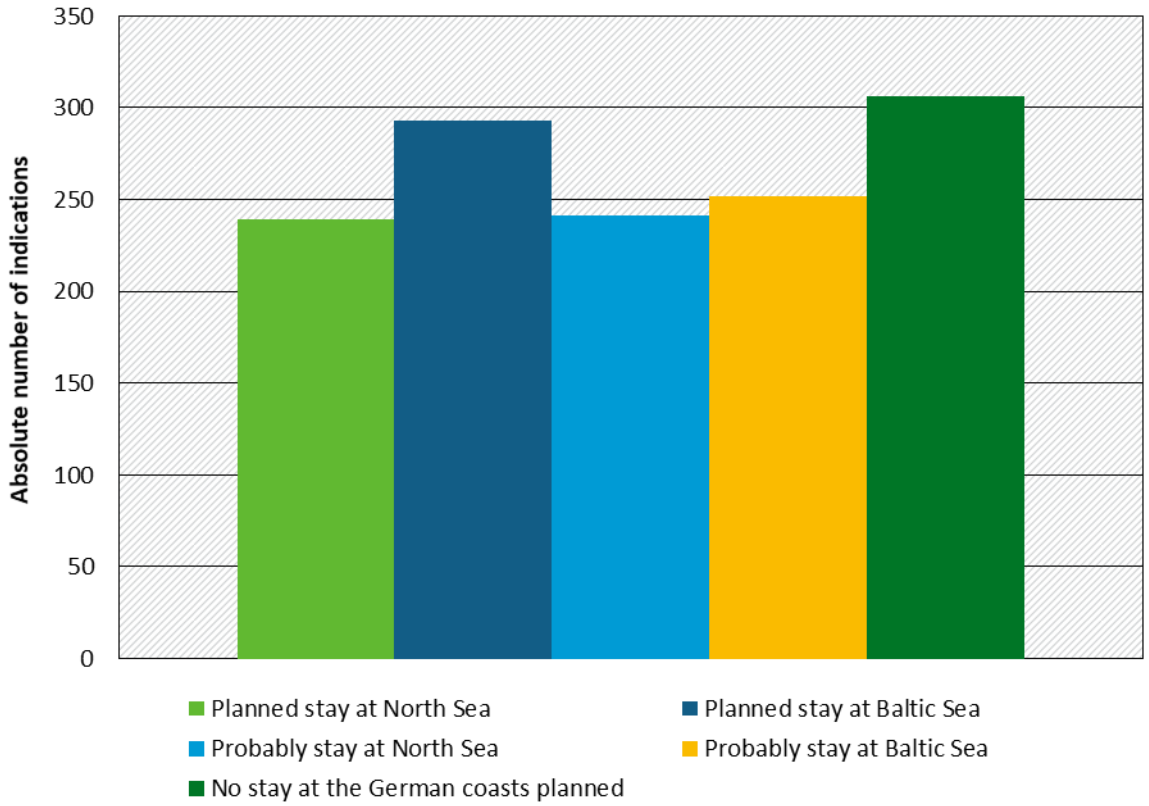
Figure 6 Substitutes in travel destinations



Source: Own data and presentation.

Moving to potential future visits respondents were subsequently asked whether they planned to spend leisure time at the German part of the North or Baltic Sea. Figure 7 reveals that only 28.8 percent of the respondents have no intentions at all to visit the German North or Baltic Sea in the future. 22.7 percent and 23.7 percent of the respondents will probably visit the North Sea or the Baltic Sea in the future, respectively. In addition, 22.5 percent and 27.6 percent of the respondents have already planned their next visit to the German North or Baltic Sea, respectively. In a later question, respondents were also asked to which extent it would change their recreational behavior if the status of the German marine waters would appreciate to reach GES. Almost one fifth (19.5 percent) of the respondents answered that such an improved status would induce them to visit the German marine waters more often. 50.9 percent of the respondents stated that they would use the German marine waters as before for leisure activities and 29.6 percent of the respondents answered that they did not know.

Figure 7 Planned stays at the German coasts

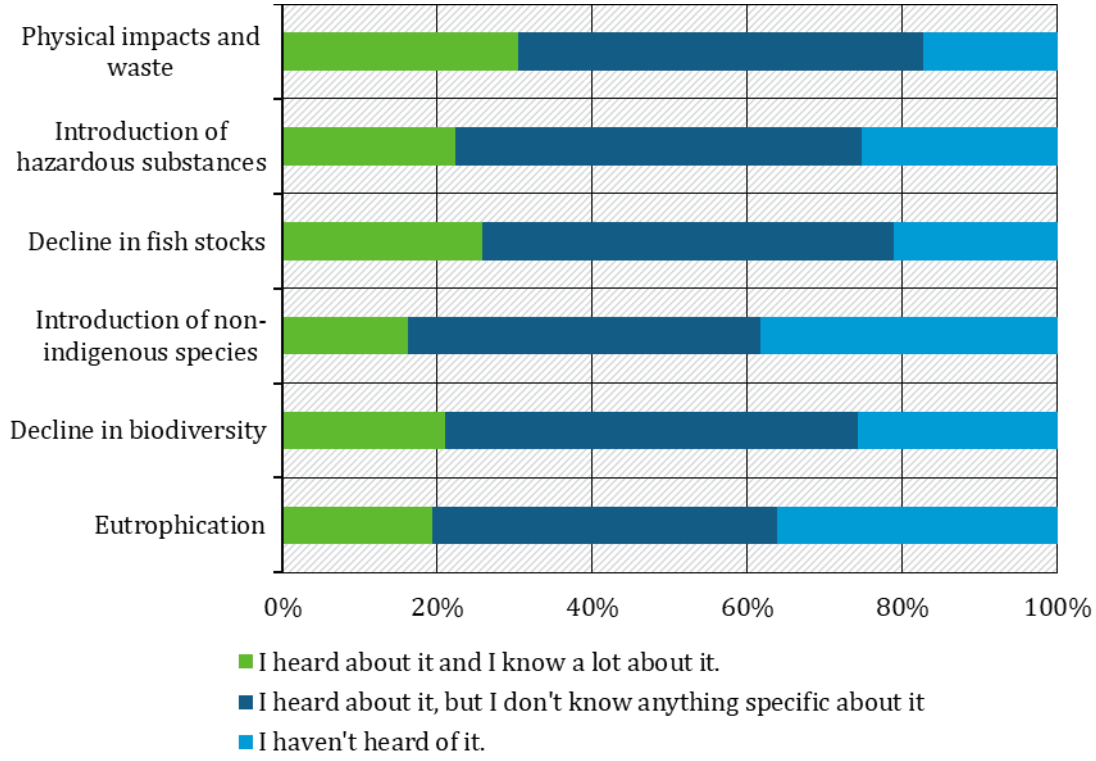


Source: Own data and presentation.

4.1.2.3 Knowledge about environmental problems and perceived importance

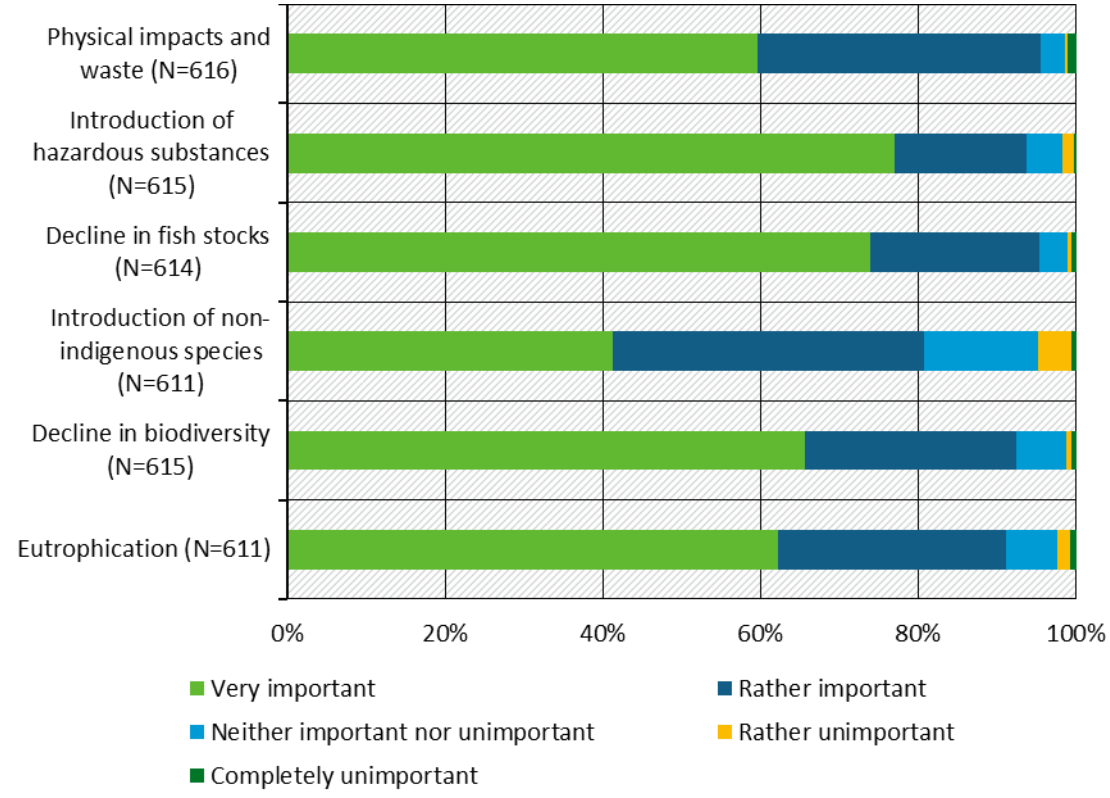
During the survey six environmental problems summarizing all descriptors defined in the MSFD were presented and explained to the respondents. These environmental problems comprised i.) Eutrophication, ii.) Decline in fish stocks, iii.) Introduction of non-indigenous species, iv.) Decline in biolocial diversity, v.) Introduction of hazardous substances, and vi.) Physical impacts and litter (Figure 8). The most well-known environmental problems were observed to be physical impacts and waste, with 30.4 percent of the respondents indicating to have heard a lot about them and only 17.4 percent of the respondents indicating to have never heard about them. The least well-known environmental problem was the introduction of non-indigenous species, with only 16.2 percent of the respondents indicating to have heard a lot about it and 38.4 percent of the respondents indicating to have never heard about it. Regarding the perceived importance of the single environmental problems (Figure 9), it can be observed that it corresponds to some extent to the knowledge about the problems. For example, the least well-known problem, arrival of non-indigenous species, is also considered the least important environmental problem. All other environmental problems are considered to be “very important” by between 60 percent and 80 percent of the respondents.

Figure 8 Knowledge about environmental problems



Source: Own data and presentation.

Figure 9 Perceived importance of environmental problems

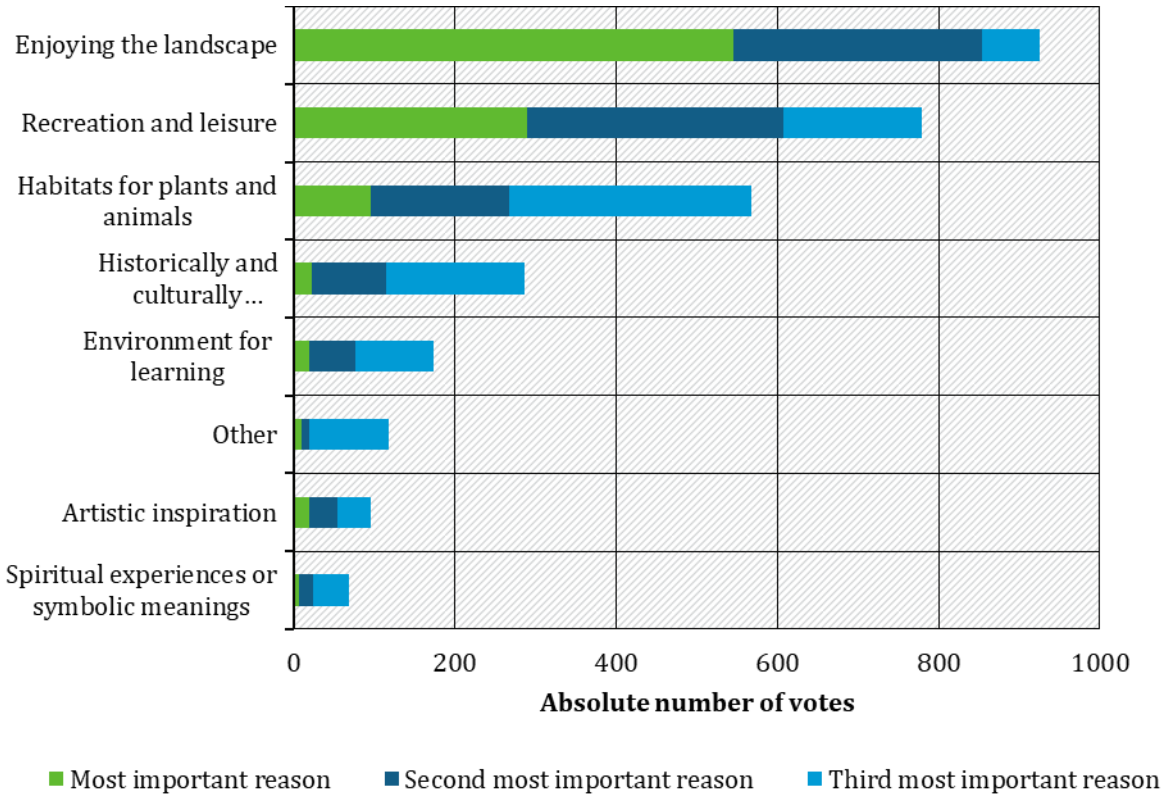


Source: Own data and presentation.

4.1.2.4 Importance of cultural ecosystem services

Respondents in the survey were asked to select and rank the three most important reasons to value the environment of the North and Baltic Sea. The list of reasons was designed to summarize and represent the most important cultural ES provided by coastal environments (Ahtiainen et al. 2019). The two most important cultural ES provided by the coasts of the North and Baltic Sea reported by survey respondents were i.) to enjoy the landscape and ii.) to spend leisure time and recreate at the coast with 926 and 780 respondents mentioning them among their three most important cultural ES, respectively (Figure 10). Both answers reflect reasons directly related to actual use of the coasts. However, 567 respondents also reported that the provision of habitat for plants and animals was one of the three most important cultural ES provided by the German coastal environments, a reason not related to direct or indirect use of the North and Baltic Sea. For comparison, Nieminen et al. (2019) report habitats to be the most important cultural ES for Finnish survey respondents (27 percent), closely followed by recreation (24 percent) and aesthetic values (21 percent). These three ES are also by far the three most important ES reported by German and Finnish survey respondents in Ahtiainen et al. (2019), even though the ranking differs slightly.

Figure 10 Importance of cultural ecosystem services



Source: Own data and presentation.

4.1.3 Willingness to pay

Of all participants who made it into the final sample (N =1,063) about 51 percent stated that they were in general willing to pay something to reach GES, 30 percent reported that they were undecided while 18 percent refused to make any contribution. After the general screening question willingness to pay for the achievement of the GES in the German marine waters was measured in two distinct ways. First, respondents were asked to select one out of 18 intervals

from a payment card. This allowed determining the lower and upper bound of their WTP. The mean lower bound was 33.3 EUR and the upper bound averaged 46.8 EUR. In a second step, participants were asked to state the exact amount they would be willing to pay in an open-ended question. Here, people stated that they were willing to pay 34.8 EUR on average (see WTP_point in Table 8 below). Some participants chose an interval, but refused to answer the open-ended question (92 respondents). Their exact WTP was assumed to lie at the midpoint of the interval they had chosen resulting in the variable WTP_merged. Those participants who had initially reported a general willingness to pay, but who were then unwilling to choose an interval from the payment card - 100 participants - were excluded from further analysis and were not incorporated into the regression analysis.

Table 8 Descriptive statistics of reported WTP

Variable	Variable description	Mean	SD	Min.	Max.	N
WTP_lower	Lower bound of WTP (EUR)	33.3	98.9	0.0	1000.0	963
WTP_upper	Upper bound of WTP (EUR)	46.8	141.9	0.0	1500.0	963
WTP_point	Point estimate of WTP (EUR)	34.8	82.9	0.0	1200.0	871
WTP_merged	Merged WTP variable (point estimates respectively mid points of intervals)	43.9	122.5	0.0	1250.0	963

Source: Own data and presentation.

All survey participants who reported to be unwilling to pay were asked about their reasons for not wanting to contribute. Moreover, the respondents who had a positive WTP were asked for their reasons for being willing to pay.

The majority of people who were unwilling to contribute monetarily to the achievement of GES stated that they could simply not afford to make a contribution (29 percent). This was corroborated by the fact that these respondents had an income which was well below the mean income of other survey participants. The second most common reason was the belief that those who pollute should be the ones making a monetary contribution rather than the average citizen (25 percent). This was followed by a general doubt about whether in fact the money would be used to achieve the GES of the Seas (13 percent). The distribution of the answers can be seen in Table 9 below.

Table 9 Participants' reasons for their unwillingness to pay

Reason given	Percentage
I cannot afford to pay.	29.46%
Those who pollute should pay.	25.89%
I do not believe that the money will be used to achieve the good environmental status of the sea.	13.39%
I do not wish to pay another fee.	12.50%
Other reason	6.25%
I prefer to spend my money on other things.	4.46%
The target year (2040) feels too distant.	2.68%
The state of the sea is good enough.	2.08%
I do not believe that the good environmental status is achievable.	2.08%
I do not care about the state of the North Sea or Baltic Sea.	1.19%

Note: N= 336

Source: Own data and presentation.

Of those who stated a general WTP, about 39 percent expressed that their motivation was rooted in a concern for future generations. A third of the respondents ascribed their WTP to a general appreciation for habitats, suggesting that they were motivated primarily by concerns about biological diversity. Motivations related to the personal use of the seas as recreational area were expressed by a much smaller percentage of people (13 percent). Table 10 depicts the distribution of the answers given to this question.

Table 10 Participants' reasons for being willing to pay

Reasons given	Percentage
I would like to preserve an intact North and/or Baltic Sea for future generations.	38.87%
The existence of intact habitats for animals and plants in the North and/or Baltic Sea is important to me.	31.13%
I want to make sure that I have the opportunity to use the North and/or Baltic Sea for recreation and leisure in the future.	12.90%
I want to ensure that other people of my generation can use the North and/or Baltic Sea for recreation and leisure.	11.94%
I use the North Sea and Baltic Sea for leisure activities.	5.16%

Note: N =619

Source: Own data and presentation.

Furthermore, 44 percent stated that they were very certain that their stated WTP was an accurate reflection of what they were willing to pay. Of the remaining participants only about 1.5 percent reported to be very uncertain about their WTP while the rest was in between these two extremes. Participants who reported being unable to state an exact WTP received a follow-up question to explore the reasons behind their uncertainty. Table 11 lists the answers they gave.

Table 11 Reasons for Inability to state WTP

Reason for Inability to state WTP	Percentage
I am uncertain about my ability to pay.	40.74%
I do not believe that the money generated through the tax will in fact be used to achieve the GES.	25.93%
I am not sure whether the GES can be achieved at all.	17.27%
I did not receive enough information.	11.11%
Another reason	4.95%

Note: N=81

Source: Own data and presentation.

Among those people who reported to be unsure about whether they would like to make a monetary contribution, the most common reason given was the fact that they were unsure about their ability to pay (41 percent). This was consistent with the fact that these survey participants did have a below-mean income. However, this might not be the main reason for their uncertainty about the willingness to pay as further analysis showed, that those uncertain about the ability to pay were also those less likely to let environmental considerations affect their day to day behaviour. In addition to that, 25 percent expressed doubt about whether the fee would in fact be used to achieve the GES of the German marine waters. The majority of participants would split their monetary contribution to achieving the GES evenly between the two seas (80 percent). Among those who had a clear preference for one of the two seas, the North Sea was, by a small margin, slightly more popular than the Baltic Sea.

Table 12 Preferred distribution of the money between the Seas

Preferred distribution	Percentage
Evenly distributed between North Sea and Baltic Sea	80.64%
The majority should go toward the North Sea	8.00%
The majority should go toward the Baltic Sea	6.24%
Everything for the North Sea	3.84%
Everything for the Baltic Sea	1.28%

Note: N= 625;

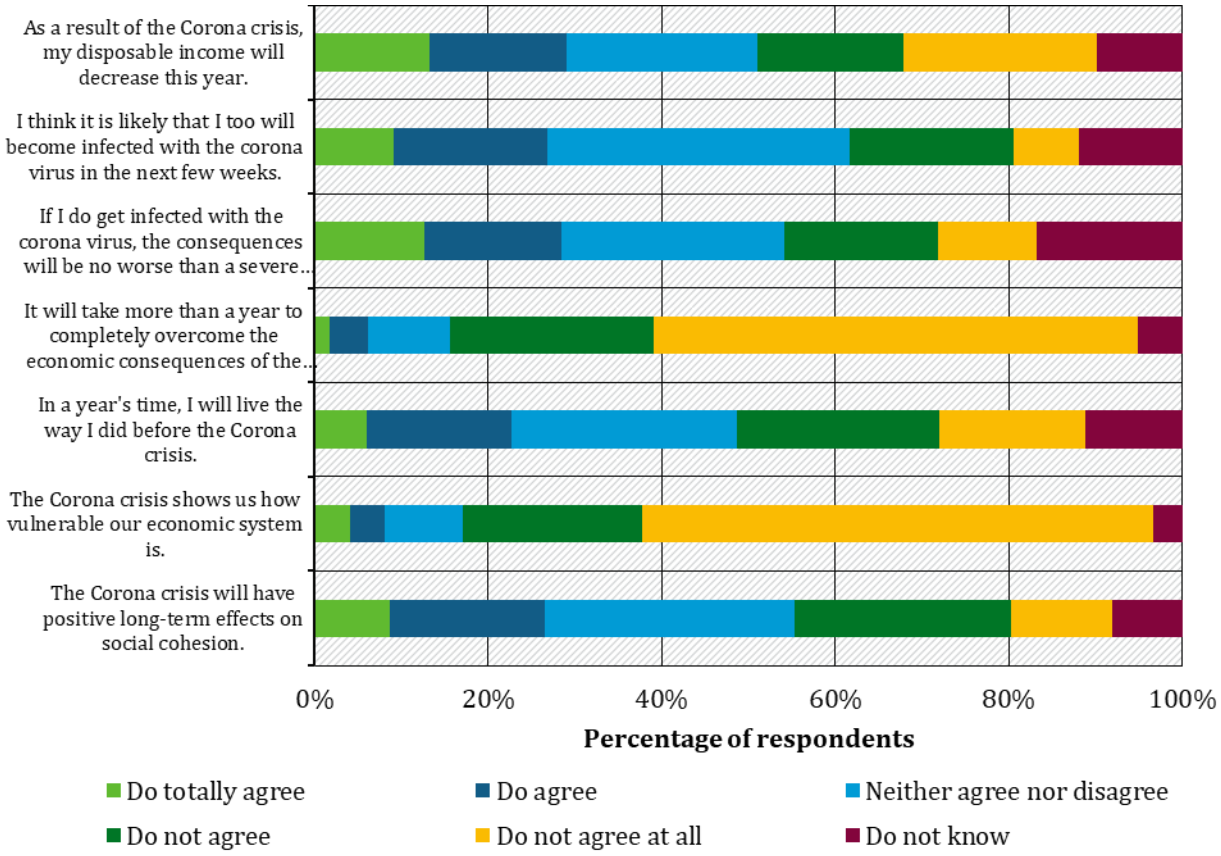
Source: Own data and presentation.

4.1.4 Further debriefing questions

4.1.4.1 Assessing the impact of COVID-19 on participants' responses

The survey included a set of questions investigating the potential impact of the COVID-19-pandemic on the situation of the respondents (n=1,063) to control for the very special situation having arisen early in the year 2020. The results depicted in Figure 11 overall show that concern about the impacts of the COVID-19-pandemic on the respondents' lives was relatively low. The biggest concern was that the respondents' disposable income would decrease due to the COVID-19-pandemic in the current year. 29.1 percent of the respondents rather or fully agreed to this statement. However, respondents seem to trust the long-term stability of the economic system: Only 6.2 percent of the respondents rather or fully agree to the statement that it will take more than a year to overcome the economic consequences of the pandemic, and only 8.1 percent rather or fully agree to the statement that the pandemic shows us how vulnerable the economic system is. Even though many respondents expect to get infected with COVID-19 (26.9 percent), they also believe that an infection will not induce more severe consequences than getting a cold (28.4 percent). Finally, 22.7 percent of the respondents rather or fully agree to the statement that in a year's time they will live their lives as before the pandemic and 26.5 percent of the respondents even rather or fully agree to the statement that the pandemic will have positive long-term effects on social cohesion.

Figure 11 Impact of COVID-19 on the respondents



Source: Own data and presentation.

4.1.4.2 Certainty about willingness to pay and consequences of the survey

Most participants indicated to find it easy to answer the questions about their willingness to pay for reaching the GES of the seas (35 percent) and only about 19 percent reported difficulties with the questions. The remaining participants did not report any difficulties.

Furthermore, and as can be seen in Table 13, 33.6 percent of the participants think that their willingness to pay will be considered in future policy making. Only around 16 percent state to believe that their statements definitely won't have an influence.

Table 13 Respondents' assessment of the consequentiality of their answers

My statement about my willingness to pay will…	Percentage
Definitely have an influence	6.49%
Rather have an influence	27.09%
Rather not have an influence	39.04%
Definitely not have an influence	15.52%
I do not know	11.85%

Note: N =1,063
Source: Own data and presentation.

4.1.4.3 Environmental behaviour

A set of control questions was asked on how environmentally friendly people behave. Opting for eco-friendly packaging while grocery shopping was taken to be a proxy for environmentalist behaviour. Participants were asked to report whether avoiding environmentally unfriendly packaging while grocery shopping was something they cared about. Table 14 below shows the answers given by participants.

Table 14 Participants' grocery shopping behaviour

Answer	Percentage
Do not agree at all	4.33%
Do not agree	7.71%
Neither agree nor disagree	20.60%
Do agree	41.49%
Do totally agree	24.74%
Do not know	1.13%

Note: N =1,063
Source: Own data and presentation.

4.2 Regression results

4.2.1 Protest responses

An important issue when analysing data from stated preference surveys is how to deal with protest responses. Although the literature is clear that protest responses may be a concern, there is no agreed best practice to address these problems (Johnston et al. 2017). The challenge is to distinguish between protest answers and genuine zero WTP values. Following the definition of Nieminen et al. (2019) the subsequent stated reasons for unwillingness to pay were considered to be protest answers (see also Table 9): "I am unwilling to pay because I do not believe that it is possible to achieve a good status", "I think that those who pollute should pay more", "I do not want to pay any extra tax" and "I do not believe the money will be used for the purpose". All other participants who gave different reasons for their unwillingness to pay were assumed to have a true zero WTP. In total, 181 respondents could be considered protesters in this sense.

4.2.2 Model specification and interpretation

Two different sets of models were estimated to analyze the determinants of WTP and to predict mean WTP and confidence intervals for aggregate WTP of the general population in Germany. Firstly, we implemented basic OLS and interval regression models to explain WTP. With this approach we closely followed Nieminen et al. (2019) also using the same set of explanatory variables. The dependent variables of these models were the natural logarithm (ln) of WTP_merged and WTP_interval (Table 8), respectively. Again, in line with Nieminen et al. (2019) both the OLS and the interval models were estimated including as well as excluding protesters. All four model combinations are used to predict and aggregate WTP for the general population in Germany.

Secondly, we implemented advanced modelling approaches to explain and predict WTP. We used a double hurdle model which assumes that investing in a good or a service – here WTP to achieve GES – is explained by two different processes: First, the individual decides whether to participate in the market at all, i.e., whether she / he is in general willing to pay something. Passing this hurdle, the individual makes a decision about the quantity to consume, i.e., how much he or she is willing to pay (Gracia 2013, Crag 1971). Note that the second process still can explain a WTP of zero (second hurdle). Separating the decision process in two parts allows us to use different variables to explain each decision. In doing so the participation process could identify respondents who would never be willing anything – for instance due to protesting. The second process explains how much of the good is consumed while still allowing for zero WTP and thereby capturing people who would in principle be willing to pay, but who report zero WTP due to factors such as low income.

The dependent variable of the double hurdle model is again the natural logarithm of WTP_merged.

For both decision processes of the double hurdle model we tested a wide range of possible explanatory effects including those already implemented in the OLS and interval regression models. In addition, the double hurdle model included the belief in policy consequences of the survey, knowledge about environmental problems in the Baltic and North Sea area, a statement about environmentally friendly behavior, and an indicator for whether the respondent had visited the Baltic or the North Sea.

Following Carson and Groves (2007) the belief in policy consequences of the survey (Section 4.1.4.2) was coded as an indicator which adopts a value one if a respondent believes that his or her responses will definitely not be taken into account (165 respondents) and zero otherwise (776 respondents). The variable Knowledge is a continuous aggregate variable which captures how much prior knowledge the survey participants had about the environmental problems in the Baltic and North Sea (see Section 4.1.2.3). The mean of this figure is calculated to be 0.24, the standard deviation 0.27. Lastly, based on the descriptive statistics presented in Section 4.1.4.3 environmentalism is taken as an indicator for environmentally friendly behavior (347 versus 794 participants).

The choice model, which makes use of data collected through the DCE, takes the same list of explanatory variables. The dependent variable in the choice model is the choice alternative. Table 15 describes the explanatory variables used in each model. Note that all models exclude participants who could not state any WTP. Further note that the double hurdle model as well as the choice model only make use of a reduced sample size due to missing values concerning the additional variables included in these models. However, they included protest responses.

Table 15 Overview over variables included in the models

Variable	Explanation	OLS / Interval model	Double hurdle / choice model
Income	Monthly net individual income (equalized income)	Yes	Yes
Age	Age of the respondent	Yes	Yes
Female	Gender of the respondent (basis =male)	Yes	Yes
High education	Indicator education of the respondent (Basis =no university degree)	Yes	Yes
Distance	Calculated distance (km) to coast based on postal code	Yes	Yes
Household size	Size of the household	Yes	Yes
Knowledge	Summary measure about previous knowledge about environmental problems	No	Yes
Consequentiality	Indicator on beliefs about the consequences of the survey (Basis =yes, I believe my choice will influence policy-makers)	No	Yes
Environmentalism	Indicator whether respondents care for environmentally friendly food packaging (basis =no or rather no)	No	Yes
Visit	Dummy variable whether Seas had been visited before (basis =no)	No	Yes

Source: Own data and presentation.

4.2.3 Determinants of WTP

4.2.3.1 Basic OLS and interval models

The results of the basic OLS and interval regression models both, excluding and including respondents identified as protesters, are presented in Table 16. Overall, most effects are very similar across models.

Note that the reported coefficients give the effect on ln WTP. They can be interpreted as semi-elasticities with respect to the effect of a one-unit increase in the explanatory variable on WTP by exponentiating the coefficient. For example, based on the basic OLS model excluding protest responses, a one Euro increase in individual income would imply a 0.04% increase in WTP. Overall, it can be noted that WTP significantly increases with increasing income, with increasing household size, and if the respondent obtained higher education, i.e., a university degree. In contrast, WTP decreases with the age of the respondent. However, this effect is only found to be significant in the models including protest respondents. No significant effects are observed with respect to gender and, interestingly, the distance to the coast.

Table 16 OLS and interval regression models

	Excluding protest responses		**Including protest responses**	
	Dependent variable:		**Dependent variable:**	
	WTP (ln)	WTP Interval (ln)	WTP (ln)	WTP Interval (ln)
	OLS	*survreg: logistic*	*OLS*	*survreg: logistic*
Income	0.0004* (5.51)	0.0005* (5.97)	0.0003* (4.14)	0.0004* (4.60)
Age	-0.0045 (-1.24)	-0.0063 (-1.72)	-0.0085* (-2.26)	-0.0097*(-2.62)
Female	-0.2008 (-1.66)	-0.2141 (-1.77)	-0.0252 (-0.21)	-0.0426 (-0.36)
High Education	0.3383* (2.35)	0.3120* (2.17)	0.3226* (2.14)	0.3014*(2.04)
Distance	0.0003 (0.94)	0.0003 (0.87)	-0.0003 (-0.96)	-0.0003 (-0.94)
Household Size	0.3288* (6.00)	0.3368* (6.06)	0.2393* (4.18)	0.2480* (4.32)
Intercept	1.3145* (4.05)	1.1859* (5.97)	1.4859* (4.40)	1.3478* (4.01)
Log Likelihood	-1504.6	-2078.5	-1949.3	-2505.3
Sample size (N)	782	782	963	963

Notes: T-values in parentheses; *p<0.05 (t>1.96); OLS =ordinary least squares; Adjusted r-squared OLS regression =0.05 (with protesters), 0.09 (without protesters)
Source: Own data and presentation.

4.2.3.2 Double hurdle model

In addition to the models presented above a double hurdle model was estimated including an extended set of explanatory variables (Table 17). Note that respondeersnts identified as protesters are included in the estimation sample for the double hurdle model. However, the sample size (N=850) is smaller than that of the OLS and interval models estimated including protest respondents due to missing values for some explanatory variables.

Remember that the double hurdle model explains the WTP of the respondents in two distinct steps or processes (Section 3.1, Section 4.2.2).

In the first step the likelihood that people are generally interested in spending their money for achieving GES is calculated (Determinants of market participation in Table 17). In the second step the determinants of the specific WTP amount are estimated for those being principally willing to pay (Quantity decision in the table below).

Table 17 Double Hurdle Model

Variable	Coefficient (|z-value|)
Quantity decision	
Income	0.0002* (3.44)
Distance	0.0002 (0.76)
Household size	0.2030* (4.54)
Knowledge	0.5480* (2.40)
Intercept	2.2915* (8.59)
Market participation decision	
Age	-0.0090* (-3.04)
Knowledge	0.9300* (4.74)
Environmentalism	0.3792* (3.63)
Consequentiality	-1.3010* (-10.21)
Visit	0.4046* (2.94)
Intercept	0.1215 (0.62)
Log likelihood	-1341.8

Notes: Z-values in parentheses; *p<0.05 (Z>1.96); N =850
Source: Own data and presentation.

We find that the higher the age of the respondent, the lower the probability to participate in the market, i.e., to state a positive WTP to achieve GES. In contrast, the probability to participate in the market increases with the knowledge about the six environmental problems mentioned in the survey. The same is true with respect to travel behavior. Compared to those respondents who had never visited the German coast, participants indicating that they had visited the North and Baltic Sea in the past are more likely to state a positive WTP. Furthermore, it is more likely to observe a positive WTP if the respondent has a positive attitude towards environmentally friendly behavior. The opposite effect occurs if the respondent believes that his or her answers have definitely no impact on policy making.

Concerning the determinants of the amount of WTP we find that WTP increases with income. The same effect is observed for the number of people living in the household and the knowledge about the environmental problems in the North and Baltic Sea. As in the OLS and interval models the distance to the coast does not have a significant effect.

4.2.4 Aggregate consumer surplus estimates

Following Nieminen et al. (2019) the aggregate benefit estimates presented in this section are based on the OLS and interval regression models presented in section 4.2 of this report. We present two sets of estimates using each model (Table 18): the first set is estimated based on a

sample that excludes protest responses following Nieminen et al. (2019), the second set is estimated based on a sample that includes protest responses for comparison. In addition, we also report aggregate benefit estimates based on the double hurdle model including protest responses as presented in Section 4.2.1.

Multiplying mean WTP (56,24 EUR) with the total adult population in Germany (69.5 million people as of December 31, 2019), the aggregate benefits of reaching GES in the German North and Baltic Sea by 2040 amount to 3.902 billion EUR per year for the basic interval regression model excluding protest responses and to 4.566 billion EUR per year for the basic OLS regression model excluding protest responses (mean WTP =65.71 EUR). Similar to findings by Nieminen et al. (2019) we also observe that WTP estimates based on the interval models are smaller than WTP estimates based on OLS regressions using point estimates. Including all zero WTP values in the regressions even though respondents are most likely protesters, we find mean WTP values that are approximately 15 Euros below estimates excluding protest responses for each model class respectively. Mean aggregate benefit estimates under these conservative assumptions amount to 2.390 billion EUR per year for the interval regression and 3.525 billion EUR per year for the basic OLS regression.

Mean individual WTP estimated from the double hurdle model amounts to 61.6 EUR per person and year. Note, however, that this prediction only holds for those people that have passed the first hurdle, i.e., for those respondents with a positive probability to participate in the market and to have positive WTP in principle. This probability is estimated to amount to 67.5%. Consequently, the mean individual WTP is in this case not multiplied with the full adult population in Germany as for the OLS and interval models. In contrast, it is multiplied only with 46.9 million people accounting for the probability to participate in the market, i.e., to have a positive WTP in principle. The result is that mean aggregate benefits of reaching GES in the German North and Baltic Sea by 2040 amount to 2.889 billion EUR per year based on the double hurdle model.

Table 18 Predicted WTP and aggregate benefit estimates with confidence intervals

	OLS (basic excluding protest responses)	Interval (basic excluding protest responses)	OLS (basic including protest responses)	Interval (basic including protest responses)	Double hurdle (extended including protest responses)
Mean WTP (EUR/person/year)	65.71	56.24	50.73	41.95	61.60
95% confidence interval of mean WTP (EUR/person/year)	54.90-76.53	46.76-65.72	41.78-59.69	34.39-49.51	52.20-70.99
Aggregate benefits (BEUR/year)	4.566	3.908	3.525	2.915	2.889
95% confidence interval of aggregate benefits (BEUR/year)	3.815-5.318	3.249-4.567	2.903-4.148	2.390-3.440	2.448-3.330
Sample size (N)	782	782	963	963	850

Notes: Aggregate benefits for OLS and interval models calculated based on an adult population of 69,488,809 people in Germany as of December 31, 2019 (Statistisches Bundesamt 2020). Calculation of aggregate benefits for the double hurdle model takes into account that the probability to participate in the market is estimated to be 67.5%.
Source: Own data and presentation.

Given that it is standard practice in the scientific literature to exclude protest responses based on debriefing questions and considering the primarily interval nature of our data, the results from the basic interval regression excluding protest responses can be considered robust and comparable to the approach presented by Nieminen et al. (2019). Behind the background of our data with a relatively large number of zero WTP and protesters in the German sample, the results of the double hurdle model including protest responses can be considered the most conservative estimates.

4.2.5 Discrete choice experiment

Table 19 depicts marginal WTP measures derived from a latent class (LC) model. LC models are able to capture unobserved preference heterogeneity – i.e., heterogeneity that is not explained by variables that can be observed – through a discrete process which assigns respondents to different classes. Here, we assume that such heterogeneity is captured by two classes. This means that preferences are assumed to be the same within one class, but different across classes.

WTP is presented in EUR per year and person to fully achieve GES, i.e., by 100% in 2040. Remember that on each of the six choice sets participant could choose between a status quo and two alternative states of the future. Each alternative was composed of the environmental problems. Their levels – 0% (as today), 30%, 60% and 100% - indicated the share to which GES is achieved in 2040.

First of all we find that class 1 is much smaller than class 2. On average, the likelihood of being assigned to this class is 74 percent compared to only 26 percent for class 1. Also, preferences indeed differ across classes. Respondents in class 1 are not willing to pay to achieve GES

whereas WTP is estimated to be significant and positive for all attributes in class 2. WTP is quite similar for the seven environmental problems analyzed ranging from 107 EUR (eutrophication) to 76 EUR (physical impacts).

In the lower part of the table class membership is explained by a set of observed covariates. They indicate whether a respondent is more likely to be in the "WTP"-class (class 2) or in the "no WTP"-class (class1). Of those variables which have been tested the following are observed to influence class membership significantly: First, the likelihood of being in the second class and thus having a positive WTP increases with the knowledge of the environmental problems. The likelihood of being in the class with significant WTP measures in lower if the respondent stated that he or she believes that his or her answers will not have an impact on policy. Compared to those participants who had never visited the Baltic or North Sea, the probability of being assigned to class 2 is significantly higher for those who had already spent time at the German coast. No significant effects are observed for "environmentalism" and, again, for the distance of the respondents' place of residence to the coast.

Table 19 Results of the choice experiment

	Class 1	**Class 2**
	Coefficient (|t-value|)	Coefficient (|t-value|)
WTP in EUR 100% GES		
Eutrophication	15.40 (1.50)	107.70* (7.02)
Biolocial diversity	11.13 (1.29)	83.50* (5.32)
Non-indigenous species	4.86 (0.64)	102.04 (6.00)
Fish stocks	19.87 (1.89)	87.04 (6.50)
Hazardous substances	6.57 (0.73)	102.94* (6.29)
Physical impacts	14.02 (1.83)	76.48* (5.79)
Littering	12.24 (1.69)	92.47* (5.97)
Variables in membership function		
Constant		0.04 (0.14)
Knowledge		1.24* (3.13)
Consequentiality		-1.96* (9.94)
Environmentalism		0.37 (1.81)
Visit		0.73 (2.80)
Distance		0.0003 (0.51)
Visit (5 years+)		0.59 (2.22)
Class probabilities		
	26%	74%

Notes: T-values in parentheses; *p<0.05 (Z>1.96); N =850

Source: Own data and presentation.

5 Results control survey – Second wave

A second survey wave was conducted in order to control for possible impact of the global COVID19 pandemic on participants WTP. The survey design and methodology followed the same logic as in the first wave. With regards to the results the distribution of people's general WTP for the GES of the German marine waters was almost identical to the first wave, as can be seen below. In both waves about 18 percent of the respondents stated that they would be willing to pay something, about half were uncertain and about 30 percent declined to contribute.

Table 20 Comparison of general willingness to pay between samples

Answer	Percentage Wave 1	Percentage Wave 2
Yes	18.13%	18.30%
Maybe	51.37%	49.82%
No	30.48%	31.86%
Observations (N)	1063	863

Source: Own data and presentation.

A comparison of the exact amounts people were willing to pay revealed slightly lower values for the second wave. However, these differences were not statistically significant when tested by means of a Mann-Whitney-U-Test.

Table 21 Comparison of amounts people were willing to pay

Variable	Variable description	Mean	SD	Min.	Max.	N
WTP_lower Wave 1	Lower bound of WTP (EUR)	33.3	98.9	0.0	1000.0	963
WTP_lower Wave 2	Lower bound of WTP (EUR)	24.3	61.48	0.0	1000.0	806
WTP_upper Wave 1	Upper bound of WTP (EUR)	46.8	141.9	0.0	1500.0	963
WTP_upper Wave 2	Upper bound of WTP (EUR)	34.15	87.45	0.0	1500.0	806
WTP_point Wave 1	Point estimate of WTP (EUR)	34.8	82.9	0.0	1200.0	871
WTP_point Wave 2	Point estimate of WTP (EUR)	28.3	58.1	0.0	800.0	709
WTP_merged Wave 1	Merged WTP variable (point estimates respectively mid points of intervals)	43.9	122.5	0.0	1250.0	963
WTP_merged Wave 2	Merged WTP variable (point estimates respectively mid points of intervals)	29.82	61.50	0.0	800.0	806

Source: Own data and presentation.

Like in the Section 4.2.3.2 we also estimated a double hurdle for the second wave. The following table reveals that the effects are very similar with the only difference being that distance seemed to have an effect this time.

Table 22 Double Hurdle Model Second Wave

Variable	Coefficient (|z-value|)
Determinants of market participation	
Income	0.0001* (2.73)
Distance to coast	0.0006* (2.10)
Household size	0.0926* (4.54)
Knowledge	0.7627* (3.08)
Intercept	2.0769* (7.24)
Quantity Decision	
Age	-0.0128* (-3.82)
Knowledge	1.1232* (5.32)
Environmentalism	0.2600* (2.31)
Consequentiality	-2.1359* (-11.91)
Visit	0.4853* (3.26)
Intercept	0.2760 (0.18)
Log likelihood	-1171.5

Notes: Z-values in parentheses; *p<0.05 (Z>1.96); N =810
Source: Own data and presentation.

Based on the double hurdle model we again predicted WTP. Results show that mean WTP is lower for the second wave – 61.60 EUR per person (wave 1) versus 47.96 (wave 2). However, some overlap of the confidence intervals indicate that this effect is not statistically significant.

Table 23 Predicted WTP and confidence intervals

	Double hurdle (extended including protest responses)
Mean WTP (EUR/person/year)	47.96
95% confidence interval of mean WTP (EUR/person/year)	40.54-55.38

Note: Results obtained from a double hurdle model; N =810
Source: Own data and presentation.

The second wave also included a DCE, which was exactly implemented as in the first wave. The following table presents results again from a LC model this time estimated on the data obtained from the second wave. Compared to results shown in Section 4.2.5 we observe the following:
Firstly, we again have a class where respondents are not willing to pay (class 1) and a class where significant WTP is observed (class 2). Secondly, the sizes of the classes are almost the same – 25% (class 1), 75% (class 2) in wave 2 versus 26% (class 1) and 74% (class 2) in wave 1. Thirdly, taking the figures from class 2, WTP is again lower in the second wave.
This effect is most pronounced for non-indigenous species – 102.04 EUR (wave 1) versus 33.22 EUR (waver 2). However, other WTP measures (biolocial diversity) are very similar – 83.50 EUR (wave 1) versus 84.46 EUR (wave 2).

Table 24 Results of the choice experiment

	Class 1	Class 2
	Coefficient (|t-value|)	Coefficient (|t-value|)
WTP in EUR 100% GES		
Eutrophication	4.75 (0.52)	63.11* (4.81)
Biological diversity	13.40 (1.53)	84.46* (6.15)
Non-indigenous species	-1.03 (0.12)	35.22* (2.75)
Fish stocks	-1.40 (0.14)	50.33* (3.84)
Hazardous substances	10.37 (0.83)	77.98* (5.46)
Physical impacts	7.94 (0.86)	64.21* (5.43)
Littering	1.09 (0.17)	52.64* (4.20)
Variables in membership function		
Constant		1.22* (2.06)
Knowledge		1.04* (2.36)
Consequentiality		2.08* (8.76)
Environmentalism		0.67 (2.68)
Visit		0.75 (2.63)
Distance		0.0005 (0.82)
Age		0.02* (3.20)
Class probabilities	25%	75%

Notes: T-values in parentheses; *p<0.05 (Z>1.96); N =810

Source: Own data and presentation.

In order to investigate why WTP in the second wave is – although not statistically significant – lower, we analyzed a wide range of control questions. They, however, did not provide us with any hints why people taking part in the second wave indicated lower levels of WTP.

Two examples are presented in the following:

Table 25 depicts how people think about their financial situation in one year from now. Results show an even distribution of the answers with the biggest group reporting no expected changes.

Table 25 Participant's expectations with regard to their financial situation

Answer	Percentage
Worse than today	19.46%
Identical	67.67%
Better than today	12.86%

Note: N =863

Source: Own presentation.

Lastly, we wanted to know whether environmental protection had become more or less important within the last six months, i.e., from March to September 2020. Table 26 reveals that the importance of environmental problems increased for respondents thus disproving the hypothesis that environmental issues become less relevant in times of financial hardship.

Table 26 Perceived importance of Environmental Issues within the last six months

Answer	Percentage
Much more important	8.34%
More important	36.6%
Neither nor	49.9%
Less important	3.59%
Far less important	1.5%

Note: N =863

Source: Own presentation.

6 Conclusions

6.1 Summary

The aim of this project was to contribute to the German status assessment report due by 2024 through estimating the cost of degradation of the German marine environment. To do so a WTP study was conducted employing the CVM. We thereby followed a thematic approach which assumes that the costs of degradation of the marine environment can be derived from the difference between the good status of the marine environment and the current status. The costs of degradation were then approximated by the loss of benefits resulting from the fact that the GES has not yet been achieved.

In total we collected 1,063 interviews in March 2020. Following an OLS model and Nieminen et al. (2019) we estimated the benefits of achieving GES to be 65.71 EUR per person and year. This amounts to an aggregate of 4.566 billion EUR for Germany.

In addition, we extended the modelling procedure by Nieminen et al. (2019) applying a double hurdle model. Predicted WTP from this approach amounted to 61.60 EUR per person and year resulting in an aggregate of 2.889 billion for Germany. Since the double hurdle included protest responses WTP estimates from this model can thus be seen as a more conservative measure for achieving GES.

Over all model specifications we consistently found that WTP decreases with the age of the respondent. WTP increases with the household's income, and if the respondents had already visited the Baltic or North Sea, prior knowledge about the environmental problems of the marine waters as well as a positive attitude towards environmentally friendly behaviour. WTP was lower for those participants who believed that their survey responses definitely do not have an impact on policy.

To complement these results, we employed a DCE in order to derive marginal WTP for each individual environmental problem. Compared to the former valuation technique this method yielded much higher WTP estimates. As a consequence, the results from the CVM may be seen as a lower bound or conservative estimate of the benefits to achieve GES.

In order to control for possible impacts of the COVID19 pandemic, a second wave of the survey was realised in September 2020 with a total of 863 participants. WTP estimates based on data from the second wave tended to be, although not statistically significant, lower compared to those from wave 1. However, the analyses of several debriefing questions did not allow us to conclude that this effect is due to the COVID19 pandemic.

6.2 Comparison of results to former studies

The monetary value estimates derived in the project cannot be directly compared to earlier studies due to different regional foci, different MSRL predictors covered, and different valuation methods used. However, a comparison that considers these differences can help to classify the results of the current project.

The only study in the German context that has used the CV method before is Ahtiainen et al. (2014) who derived monetary benefit estimates for reaching the targets of the Baltic Sea Action plan for reducing eutrophication (i.e., nutrient load reductions) in the Baltic Sea in the year 2050. Annual mean WTP per person for Germany was 25.0 EUR for the spike model, 31.9 EUR for the extensive OLS model, and 31.2 EUR for the extensive interval regression model (in PPP corrected 2011 EUR). Taking the lowest of these values, aggregate annual benefits for reducing

eutrophication amounted to 1,706.0 million EUR for Germany with the 95 percent confidence interval ranging from 1,600.1 million EUR to 1,811.2 million EUR. The total mean WTP values per person derived in this project are larger than those derived by Ahtiainen et al. (2014) (see section 4.2.2) ranging from 50.7 EUR/person/year to 65.7 EUR/person/year (across all five models presented). Note, however, that this mean individual WTP refers to both the North Sea and the Baltic Sea. Given that around 81 per cent of our respondents stated that the monetary amount should be split evenly between the two Seas, only 25.4 to 32.8 EUR/Person/year pertain to the Baltic Sea, which is well comparable to the WTP amounts elicited by Ahtiainen et al. (2014). This translates into comparable aggregate annual benefits pertaining to the Baltic Sea, which range from 1,444.7 to 2,289.0 million EUR for Germany based on the current study. Note moreover, that other design elements differ between the studies. For example, our study covers a broader range of MSFD descriptors in comparison to only considering eutrophication. Moreover, increases in the price index over time would also need to be taken into account.

Nieminen et al. (2019) and Nordzell et al. (2020) present the two foreign studies that are most closely related to the current study and merit comparison. Both studies estimate monetary benefits of reaching GES by 2040 in the sea areas belonging to Finland and Sweden, respectively, based on the application of the CV method. For Finland, mean WTP is estimated to range from 104.5 EUR/person/year to 123.2 EUR/person/year depending on the regression model used. Taking the lowest of these values which refers to the extensive interval regression model, annual aggregate benefits for Finland would be 431.5 million EUR per year based on an adult population of 4.13 million people (Nieminen et al. 2019). Thus, mean WTP per person and year is almost twice as large in Finland compared to Germany. Interestingly, however, Ahtiainen et al. (2014) have also found a very similar relationship between WTP estimates among countries. They estimated mean WTP/person/year to be 41.8EUR for Finland based on the spike model, which yielded the lowest WTP estimates across models, compared to 25.0 EUR for Germany (see above). Consequently, also Ahtiainen et al. (2014) observed individual annual WTP estimates in Finland to be almost twice as large as those for Germany.

In the basic OLS and interval models, we used the same explanatory variables as Nieminen et al. (2019), namely income, age, gender (female), high education, distance, and household size. In addition, we used the variable knowledge in the double hurdle model which was calculated as the knowledge variable in the Finnish study. Comparing the descriptive statistics of these variables among the countries, it becomes obvious that Finnish respondents on average live very much closer to the Sea (~60km) than German respondents (~285km). This carries over to on average much lower prior knowledge about the environmental problems pertaining to the Baltic and the North Sea. The indicator representing the knowledge about the six environmental problems described to the respondents amounted on average to 0.80 for the Finnish study and to 0.24 for the German study (on a range from zero to one). Moreover, former studies have shown that Finnish residents tend to use the Baltic Sea coast much more frequently for recreational pruposes also on a day-to-day basis while German residents more often are tourists to the Baltic Sea coast that only visit once or twice a year (Bertram et al. 2020). Consequently, we would hypothesize that the differences in mean individual WTP between Germany and Finnland are explained by a different geographical set-up, with Germany's territory extending much further away from the coasts of the Baltic and North Sea than the Finnish territory from the coast of the Baltic Sea, which then translates into a different pattern of actual usage of the coasts, and differences in awareness and concernedness about the environmental problems pertaining to the national Seas.

The results of Nordzell et al. (2020) show a mean annual WTP of 1,075 SEK/person/year (104.2 EUR/person/year) based on a regression using a combination of point WTP and midpoints of

intervals and excluding protest responses. Using an interval regression model, mean annual WTP amounts to 1,061 SEK/person/year (102.8 EUR/person/year). Nordzell et al. (2020) also report an uncertainty band of individual annual WTP based on different ways of dealing with zero WTP responses. Excluding all zero WTP responses implies a mean WTP of 1,138 SEK/person/year (100.6 EUR/person/year) while including all zero WTP responses in the sample leads to an estimate of 873 SEK/person/year (84.6 EUR/person/year). Based on an individual mean annual WTP of 104.2 EUR/person/year and a Swedish adult population of 7,610,775 people, aggregate WTP for deriving GES by 2040 is 793.0 million EUR per year.

Table 27 shows a comparison between individual and aggregate WTP estimates across the most recent and comparable Finnish, Swedish and German studies. Note that the values in the table have been corrected for purchasing power parity with 2019 Finnish consumer prices as the basis. The range of values reported covers the whole range of models presented in the three studies, respectively.

Table 27 Comparison of WTP estimates across countries

	Mean individual WTP (EUR/person/year)	Aggregate WTP (million EUR/year)
Finland	107-125	440-519
Sweden	85-110	665-875
Germany	51-66	3,321-5,248

Notes: Estimates are adjusted for purchasing power parities with baseline 2019 Finnish consumer prices.
Source: Nieminen et al. (2019), Nordzell et al. (2020), this study; own calculations.

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