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Public preferences for policy intervention to protect public health from maritime activities: A 14 European country study

B.R. Roberts [a,*], M.P. White [a,b], S.M.C. Davison [a], O. McMeel [c], C. Eatock [a], P. Kellett [d], J.-B. Calewaert [c], L.E. Fleming [a]

[a] European Centre for Environment and Human Health, University of Exeter, Knowledge Spa, Royal Cornwall Hospital, Truro, Cornwall, UK
[b] Cogntive Science HUB, Department of Psychology, University of Vienna, Austria
[c] Seascape Belgium, Brussels 1000, Belgium
[d] European Marine Board, Ostend, 8400 Belgium

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ABSTRACT

Marine ecosystems provide a wide range of goods and services that directly and indirectly benefit economies and support human health and wellbeing. However, these ecosystems are vulnerable to anthropogenic influences such as climate change, pollution and habitat destruction. The European Union (EU) recognises the role of the blue economy in providing jobs and contributing to economic growth, with the EU Integrated Maritime Policy being a cross-sectoral framework within which maritime activities are managed and coordinated. Sustainability is a central tenet, ensuring that sectors such as aquaculture and offshore wind energy, which are earmarked for growth, must develop in ways that do not negatively impact the health of the marine environment. However, there is currently little consideration of how these activities might impact public health. The current research used survey data from 14 European countries to explore public perceptions of these issues, broadly focusing on 10 maritime activities, with a specific focus on five activities related to the EU's 2012 Blue Growth Strategy. The respondents appreciated the interconnections between these maritime activities, environmental protection and public health, as well as the potential trade-offs. Preferences for policy intervention to protect public health from different activities were predicted by both marine contact (marine sector employment, recreational activities) and socio-demographic (political attitudes, gender, age) variables, potentially aiding future engagement and communication initiatives. Substantive differences observed across countries in terms of policy preferences for different activities, however, warn against generalising for the European population as a whole.

1. Introduction

1.1. Overview of oceans and human health

Marine environments provide a multitude of globally important 'ecosystem services' beneficial for human health and wellbeing (Hattam et al., 2015), including provisioning services (e.g. seafood, medicines (FAO, 2018)), regulatory services (e.g. climate regulation, nutrient recycling (van den Belt et al., 2016)), and cultural services (e.g. recreation/tourism (Rees et al., 2010)). Seafood alone is a key source of protein for 3.2 billion people, especially in developing countries (FAO, 2018). However, human actions have severely degraded global marine ecosystems' abilities to deliver these services, with direct and indirect implications for the health of billions of people (Depledge et al., 2019; Fleming et al., 2019; Borja et al., 2020). Collapsing fish stocks due to overfishing and habitat destruction (FAO, 2018), chemical/oil spills (Peres et al., 2016), food poisoning from contaminated seafood (Yaktine and Nesheim, 2007; Berdalet et al., 2016), and gastroenteritis from recreation in polluted bathing waters (King et al., 2014) are just some of the most well-researched and obvious threats. The urgency of the situation is to be highlighted, and potential solutions developed, in the United Nation's Decade of Ocean Science for Sustainable Development (2021–2030; https://en.unesco.org/ocean-decade).

Recent years have seen a marked growth in the global ocean economy, with the OECD predicting that it could reach a gross value added of around $3 trillion by 2030 (OECD, 2016). With a coastal population of around 214 million people (~45% of the total population; European Commission, 2019a), the European 'blue economy' accounted for nearly

* Corresponding author.
E-mail address: B.Roberts3@exeter.ac.uk (B.R. Roberts).

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5 million jobs and a turnover of ~€750 billion in 2018, up 11.6% on 2017 (European Commission, 2020a). The EU Blue Growth strategy, launched in 2012 (European Commission, 2012) as Europe emerged from a global recession, aimed to grow Europe's blue economy with a focus on several maritime sectors identified as having potential for growth: aquaculture, renewable energy (e.g. offshore wind farms, tidal, wave), biotechnology (e.g. medicines, food), seabed mining for mineral resources (e.g. gold, cobalt), and coastal tourism. Although careful to acknowledge the need for growth in these sectors to be sustainable to ensure healthy marine ecosystems (European Commission, 2017), the strategy said little about the protection of human health and wellbeing, other than recognising the recreational value of high quality bathing waters and pristine marine habitats through the EU's Bathing Waters directive (European Union, 2006).

In May 2021, the European Commission published a communication on a new approach for a sustainable blue economy in the EU (European Commission, 2021), recognising the need to shift the focus from "blue growth" to a *sustainable* blue economy to achieve the objectives of the European Green Deal (European Commission, 2019b), an action plan to make the EU economy sustainable and achieve zero net emission of greenhouse gases by 2050. The Green Deal directs more attention to the potential of ocean resources to alleviate demands on land-bases resources, particularly for alternative sources of protein and renewable energy. It also recognises the need for a healthy and resilient ocean to mitigate climate change. While healthy marine ecosystems are clearly good for human health, there is nonetheless a need to highlight the downstream implications for human health of non-sustainable use of marine resources (Depledge et al., 2019; Fleming et al., 2021), and to better understand the public's beliefs and preferences in this area (Maguire et al., 2019).

To explore these issues, an international, interdisciplinary collaboration of marine scientists, medical and social scientists, and governance experts are working with national (e.g. Public Heath England (UK), National Institute for Public Health and the Environment - RIVM (Netherlands)) and international (e.g. World Health Organisation) health bodies to explore the links between the marine environment and human health in Europe. Central to these efforts were two EU Horizon 2020 funded projects: 'BlueHealth' (www.bluehealth2020.eu) and 'Seas Oceans and Public Health in Europe' (SOPHIE, www.sophie2020.eu) focusing on Oceans and human health (OHH). OHH is the study of the complex interactions between the health of the ocean and the physical and mental health and wellbeing of humans.

Although the field originated in the United States (Sandifer et al., 2004; Fleming et al., 2006), the European context provides unique opportunities and challenges, and requires its own bespoke research programme (Moore et al., 2013; Fleming et al., 2014). With four seas and two ocean basins, 185,000 km of coastline, and 44 countries (including 27 EU member states), the complexities of OHH in Europe are significant. For instance, while aspects of management of European marine waters are based on EU and international governance frameworks (McMeel et al., 2019), many health policies are the responsibility of individual nation states (Borja et al., 2020).

The current paper presents findings from one part of this effort. In particular, key results of a 14 European country citizen survey conducted as part of the SOPHIE project, which explored public perceptions of the links between oceans and human health in the European context. Understanding public, as well as scientific and policy maker, perceptions of these issues is crucial for several reasons, not least because of the need for democratic accountability of judgments being made about the marine environment that could affect the health of millions of European citizens (European Commission, 2019b).

1.2. The importance of understanding public perceptions about environment and health

The use of citizen surveys to understand how the public perceives environmental issues, such as climate change (Lorenzoni and Pidgeon, 2006; Poortinga et al., 2019; Bouman et al., 2020), have been conducted regularly and serves several purposes. First, they help gauge public understanding of the links between environmental and human health in general. For instance, 78% of respondents in the most recent environmental module of the Eurobarometer tended to agree, or totally agree, that "environmental issues have a direct effect on your daily life and *health*" (italics added, European Commission, 2020b, p.35), highlighting generic awareness of the link between the environment and human health.

Second, surveys help gauge which issues are of most, and least, concern to the public (Gelcich et al., 2014); and which policy efforts are most likely to receive public support (Bouman et al., 2020). Such knowledge can help policy makers identify, sometimes in advance, which issues are likely to become 'amplified' in the population (i.e. greater concern than might be expected based on a formal assessment of risk by experts), and which 'attenuated' (i.e. lower concern than might be expected; Pidgeon et al., 2003). This can help scientists, policy makers and campaign groups identify where more work with citizens is needed, perhaps to reduce misunderstandings (Bruine De Bruin and Bostrom, 2013; Boase et al., 2017), or where modifications in policy are needed to make "managerial and policy priorities more responsive and accountable to public values" (Gelcich et al., 2014, p 2). Finally, they can identify demographic predictors of environmental concern and policy preferences (e.g. Poortinga et al., 2019), which can again inform specific actions, communication and outreach activities.

1.3. Relevant previous multi-country citizen survey research

Although we know of no studies that have directly explored the perceived impacts on human health of maritime activities, and specifically the five priority areas identified in the 2012 Blue Growth strategy, two earlier multi-European country citizen surveys and a review of multiple studies are relevant. Conducted in 2011 using online panel samples of approximately 10,000 people in 10 European countries, Gelcich et al., (2014) were among the first to explore public perceptions of anthropogenic impacts on ocean health. This survey explored a variety of topics, from those related to climate change (e.g. 'ocean acidification' and 'sea level rise'), to broader issues such as 'overfishing', 'pollution' (including sewage and oil pollution) and 'invasive species'. Respondents felt they were most informed and concerned about 'ocean pollution', and least concerned and informed about 'jellyfish blooms'. Although informative, the focus was on ocean, rather than human, health; and the research was interested primarily in potential hazards, rather than on maritime activities engaged in for growth.

Potts et al., (2016) also collected data using a multi-national survey at a similar time (December 2010 to January 2011), gathering the attitudes and concerns of 7000 European citizens towards the marine environment across seven European countries. Respondents were asked to rate their concern about five marine issues: 'pollution', 'climate change', 'food safety and availability', 'loss of species' and 'the health of the world's oceans'. As with Gelcich et al., (2014), concern was highest for 'pollution' in all seven countries. When asked how much threat to the marine environment 10 marine risks posed, respondents felt 'pollution from industry' and 'marine litter' were the biggest threats, and 'aquaculture' and 'marine renewables' the least problematic. Another key feature of this research was its exploration of individual and socio-demographic predictors of concern. Broadly speaking, it found that concern for ocean health increased with age, but was unrelated to gender, educational attainment, or how far people lived from the coast.

Finally, Lotze et al., (2018) combined data from 21 different surveys, mostly single country studies (but also Gelcich et al., 2014, and Potts et al., 2016) to explore public perceptions of anthropogenic threats to the marine environment. Again, 'pollution' was consistently ranked as the most important threat, followed by 'wild capture fisheries', 'habitat destruction', 'climate change', and 'biodiversity loss'. They highlighted

a potential lack of awareness of just how degraded marine ecosystems already are: although a majority of respondents felt marine ecosystems were under threat, only a minority thought their current condition was poor (Korpinen et al., 2019; Vaughan et al., 2019). Reflecting a similar lack of awareness, the majority of respondents supported the development of more marine protected areas, but generally over-estimated how much of the marine environment was already protected.

1.4. Current research

The current paper presents key outcomes of the Seas, Oceans, and Public Health in Europe (SOPHIE) survey, an international survey exploring public attitudes, perceptions, and policy preferences, with respect to the effects of human activities in the marine environment on human health and wellbeing. The SOPHIE survey builds upon the previous work on public perceptions of marine environments highlighted above (Gelcich et al., 2014; Potts et al., 2016; Lotze et al., 2018), but: i) focuses on maritime activities, including those identified as priority areas for growth in the EU Blue Growth strategy; ii) explores public perceptions of how these activities could influence human, as well as marine, health; and iii) provides a timely update on public perceptions of the impact of marine environmental change at the beginning of the UN Decade of Ocean Science for Sustainable Development (2021–2030); nearly ten years after most of the earlier research was conducted. Although the survey contained a variety of questions, here we focus on those relating to desire for policies to protect public health and wellbeing from potential threats arising from maritime activities. In particular, we wanted to address the following key research questions (RQ):

- RQ1) What are people's attitudes towards key maritime activities in terms of their potential impact on the economy, the environment and, crucially, public health?
- RQ2) How much *policy/intervention* would they support to potentially protect public health from these activities?
- RQ3) How are attitudes towards the activities, as well as situational (e.g. coastal proximity) and socio-demographic (e.g. age, gender, political orientation) factors, associated with policy preferences to protect public health?
- RQ4) Are there systematic *differences between European countries* in terms of desire for policy intervention (e.g. laws, regulations, subsidies), both in terms of: a) the average within-country level of policy preferences; and b) the direction and strength of associations of predictors of policy preferences between countries.

2. Methods

2.1. The SOPHIE survey

The SOPHIE survey was a 14-country survey developed as part of the Seas, Oceans and Public Health in Europe (SOPHIE) project funded under the EU's Horizon 2020 Framework Programme (https://sophie2020.eu/). A total of 14,167 individuals ($M_{age} = 46$, age range: 18–99 years, 6898 men and 7269 women) participated in the survey. Country selection was based on several criteria including a desire to have at least one country with a coastline on each of the European sea/ocean basins (i.e. Atlantic, Baltic, Black, Mediterranean, North, Arctic), one landlocked country with no coastline for comparison (i.e. Czech Republic), and countries with key maritime sectors (e.g. Norway). Accordingly, the 14 countries selected were: Belgium, Bulgaria, Czech Republic, France, Germany, Greece, Republic of Ireland, Italy, the Netherlands, Norway, Poland, Portugal, Spain, and the United Kingdom (which at the time of the survey was still in the EU).

The survey was administered online in March and April 2019 by international market research company YouGov using established respondent panels. Eligible participants (aged 18 and above and registered as a resident in one of the 14 countries) were invited to complete the survey by YouGov. Samples of approximately 1000 respondents per country were stratified to be nationally representative on age, gender, and region, as per previous studies in this field (e.g. Gelcich et al., 2014). Survey questions were translated into local languages where appropriate. Where possible, established scales and items from pre-existing surveys were used (e.g. the European Social Survey (ESS, 2018)) to ensure robustness and pre-translation.

The data were provided to the research team for analysis already anonymised; and ethical approval for the research was provided by the University of Exeter Medical School Ethics Committee (reference number: Nov18/B/171).

2.2. Measures

The survey consisted of four main sections: i) contact with the marine environment; ii) attitudes towards 14 maritime activities in terms of their impact on the three key domains of the economy, the environment and human health; iii) concerns and future research support for various marine threats (with some overlap with activities); and iv) socio-demographic information. Here, we focused on sections i, ii and iv, and in particular 10 of the 14 maritime activities from section ii, i.e. those with relevance to economic growth: aquaculture, offshore wind farms, deep-sea mineral extraction, producing medicines from marine organisms (i.e. one aspect of biotechnology), recreational visits, water sports, holiday cruises, commercial fishing, offshore oil/gas mining, and shipping.

Of note, although recreational visits are clearly related to coastal tourism, we prefer the phrase 'recreational visits' here because coastal respondents may not consider themselves tourists even if these visits contribute to the 'coastal tourism' economy. Although our main focus was on the first five, which are examples of Blue Growth activities, the remaining five activities were also included as key, already well established, maritime activities. Within the survey, the order in which the activities appeared for participants was randomised to avoid order effects. For additional information on how each outcome was developed, see Supplementary materials in Davison et al., 2021.

2.2.1. Outcomes

Health-related policy intervention preferences. For each of the 10 maritime activities respondents were asked: "*Some people think we need strong policies (e.g. laws, regulations, subsidies) to protect public health, while others prefer little direct intervention. How much policy intervention do you think is needed to protect public health and wellbeing from the following marine activities*?". Response options were recorded on a 7-point scale from "*very little intervention*" (0) to "*a lot of intervention*" (6) (see Bouman et al., 2020 for a similar scale with respect to climate policy support). For conciseness, we refer to these health-related policy intervention preferences as "*policy preferences*".

2.2.2. Predictor variables

Economic, environmental and health-related attitudes. Adopting a similar question to that asked by Poortinga et al. (2019) to measure climate related attitudes, participants were asked: "*On balance, how good or bad do you think the following marine activities are for: a) the economy, b) the environment, and c) human health, across Europe?*", with response options recorded on a 7-point scale from "*very bad*" (−3) to "*very good*" (+3).

Contact with the marine environment was explored in three ways: a) home proximity to the coast; b) maritime employment; and c) recreational use. *Home proximity*: Respondents were asked to select from a drop down distance menu from 'Up to 1 km' through to '>500 km'. Based on evidence of an exponential decline in coastal visits as a function of home location (White et al., 2014; Elliott et al., 2020), distance was grouped into 5 categories: ≤1 km, >1–5 km, >5–20 km, >20–50 km and > 50 km. There were also 418 (3.1%) 'don't know' responses which were placed into the > 50 km group based on the fact that many of these

respondents lived in the Czech Republic, and most of the remainder had rarely or never visited the sea in the last 12 months.

Maritime employment: Respondents were asked to "*indicate whether you or any member of your household works in any of the following professions/industries associated with the marine environment*", with occupations including shipping, commercial fishing, aquaculture, marine renewables, tourism, marine protection, and marine research. As there were insufficient numbers within specific sectors for substantive analysis, we created a binary variable of *'yes' someone in my household is employed in the marine sector vs. 'no', no one is employed in this sector*.

Recreational use: Respondents were asked: "*Which of the following recreational activities, if any, do you engage in that are related with the sea or coast?*" with 16 recreational activities mentioned including beach/coastal walking, watching the view, swimming, sea fishing, and sailing, with yes/no response options. The number of activities engaged in were then summed to create scores ranging from 0 (no activities engaged in) to 16 (all activities engaged in) for each respondent.

Political orientation. Political orientation was asked on an 11-point scale, with '0' indicating the left and '10' indicating the right. These were turned into a categorical variable of 'left-oriented' (reference group, scores between 0 and 3), 'centre' (scores between 4 and 6) and 'right-oriented' (scores between 7 and 10). We did not retain the scale as there were 2,192 missing values (including 'prefer not to answer') and we wished to include them in the analysis to keep the sample as complete as possible, so we added a further political orientation 'missing' category.

Demographics. Demographic variables included in the models were: gender (reference = male; female); age (18 to 99 years); educational attainment (reference = no degree; degree; missing); and employment status (reference = in employment; unemployed; student; retired; missing). Household income was collected in 10 income bands adjusted for purchasing power parity as a function of country. We collapsed the lowest three bands into a 'low income' category, the top three bands into a 'high income' category and bands 4 to 7 were collapsed into a 'middle income' category (reference category).

Missing data. For categorical variables, respondents who did not provide an answer or who responded as 'don't know' or 'prefer not to answer' were coded as missing and were included as such in the models. For continuous variables, such as policy preference and attitudinal responses, individuals who did not provide an answer were not included in the final analysis, in accordance with the approach utilised by Bouman et al., (2020).

2.3. Data analysis

All analyses were conducted using the statistical programme R (version 3.6.1; R Core Team, 2019). Analysis methods for each research question (RQ) are presented in turn below. Data relating to the 10 maritime activities are presented for RQs 1 and 2 below, for comparison purposes. For RQs 3 and 4 model outputs are only shown for our five key Blue Growth activities; results for the remaining activities are presented in Supplementary Materials (Table S3).

RQ1: Attitudes towards maritime activities. Activities were ranked from most to least positive in terms of sample means, and entered into a repeated-measures Analysis of Variance (ANOVA) using the lme4 package (Bates et al., 2019), with repeated contrasts exploring the significance of the difference between adjacently ranked activities. At this stage we did not adjust for other factors as the purpose of this analysis was simply to establish a rank order of attitudes towards each activity in terms of public health implications.

RQ2: Policy preferences to protect public health. A similar repeated-measures ANOVA, with repeated contrasts was used to explore the significant differences between adjacently ranked activities in relation to policy preferences.

RQ3: Predicting policy preferences. To investigate attitudinal and socio-demographic predictors of policy preferences, we ran a series of general linear mixed models, with country as a random effect (to account for country-level clustering of responses). The fully adjusted models included: all three attitudinal components (economic, environmental and health), marine contact variables (home proximity, occupation, recreation), political orientation, and socio-demographic variables (e.g. age, gender). For these models, we assumed linearity, and so to test our assumptions we also ran ordinal models for the five Blue Growth activities (see Table S4). Ordinal models were run using the clmm function from the ordinal package (Christensen, 2019).

RQ4: Exploring cross-country variance in policy preferences. The country random effects from the fully adjusted models enabled us to see the average level of policy preference for countries and thus answer part of this question. However, they were unable to tell us whether the relationships between key predictor variables and policy preferences in those models are similar or vary across countries. To explore this, we ran further models with a random slope for predictors that consistently emerged as significant in the fully adjusted models (as it turned out, for attitudes, age and gender). We used the performance package (Lüdecke et al., 2021) to compare whether the random slope models explain the data better than random intercept models produced for RQ3. Additionally, we used the predict function from the package lme4 (Bates et al., 2019) to plot individual country slopes for each of the variables of interest, across the five key Blue Growth activities.

Survey weights. Sampling was conducted to approximate representativeness based on age, gender and region within each country. Due to residual sampling issues, survey weights were provided by the data collectors to improve representativeness. The parameters package (Lüdecke et al., 2021) was used to modify our original survey weight into a format useable for linear mixed models, and this new survey weight was specified in all models. The parameters package scales the weights to create two new weights (survey weight A and B); for our analysis survey weight B was chosen, as we were most interested in the residual between-cluster (countries) variance, rather than point estimates. However for descriptive analysis, it is best to use survey weight A and so this was used to create data for Tables 1 and S2. For more detailed methodology regarding models for RQ3 and RQ4 and for a more in-depth description of the survey weights see the Supplementary Materials.

3. Results

3.1. RQ1: Attitudes towards maritime activities in terms of impact on economy, environment and health

Attitudes towards the 10 maritime activities, in terms of how good or bad they are perceived to be for the economy, environment, and human health are summarised in Fig. 1a-c. European citizens believed that all maritime activities were good for the economy (i.e. the means and 95% Confidence Intervals were above the neutral point of zero). Consistent with official estimates (European Commission, 2020a), recreational visits (coastal tourism) was ranked by respondents as the most beneficial maritime activity for the economy. Deep-sea mineral extraction and offshore oil and gas mining were rated as the least beneficial. In terms of the environment, people perceived, on average, shipping, commercial fishing, holiday cruises, deep-sea mineral extraction, and offshore oil and gas mining as bad for the environment. Four of the Blue Growth sectors (aquaculture, producing medicines (biotechnology), offshore wind farms and recreational visits (coastal tourism)) were seen as good for the environment. Finally, in terms of public health, the majority of maritime activities were seen to be positive, with the exception of deep-sea mineral extraction, oil/gas mining and shipping.

3.2. RQ2: Policy preferences to protect public health

Policy preferences for the 10 maritime activities, in terms of protecting public health, are summarised in Fig. 1d. Policy preferences to

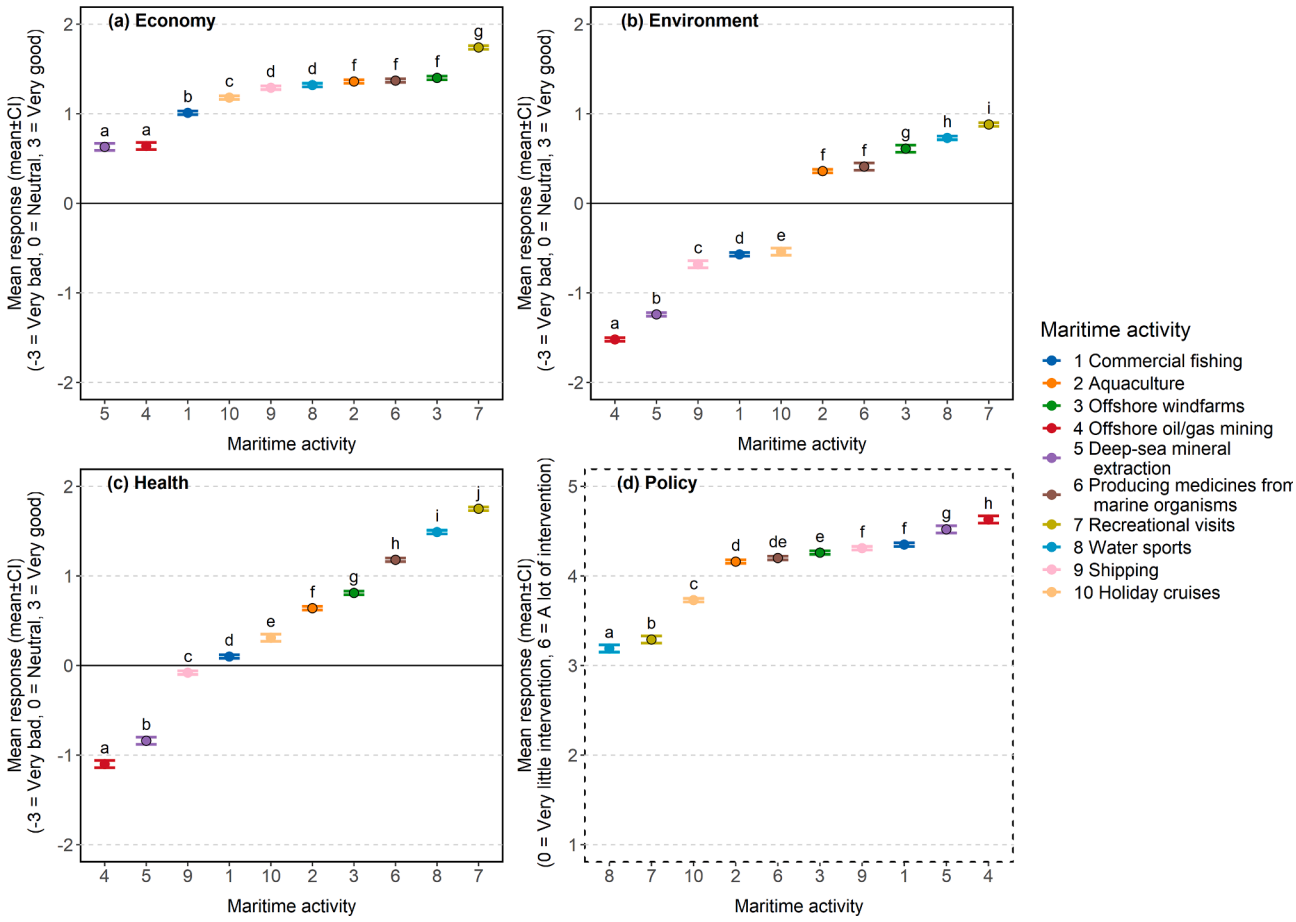

Fig. 1. Ranked mean graphs for the 10 maritime activities, showing the mean scores (coloured circles) across the 14 countries and their 95% confidence intervals ($\bar{x}$ = 12,983–13,394). Graphs a-c show public attitudes towards each maritime activity, with scores ranging from 'Very bad' (−3) to 'Very good' (+3) for: a) the economy, b) the environment, and c) public health and wellbeing. The final graph with a dashed border (d) shows the mean scores for how much policy intervention the public want to protect public health and wellbeing, with scores ranging from 'Very little intervention' (0) to 'A lot of intervention' (6). The five key Blue Growth activities: aquaculture (2), offshore wind farms (3), deep-sea mineral extraction (5), producing medicines from marine organisms (6) and recreational visits (7) are represented by coloured circles with black outlines. Letters within each graph relate to significant differences between activities, with shared letters indicating non-significance (e.g. in (a) the change in mean between activities 5 and 4 is not significant, represented by the shared letter 'a'). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

protect public health for all 10 activities were moderate (all means and 95% confidence intervals were above the mid-point of three). Consistent with beliefs about their effects on human health, intervention preferences were strongest for those activities that were thought to be most negative for the environment and for public health (i.e. oil/gas mining, deep-sea mineral extraction, commercial fishing, and shipping).

3.3. RQ3: Predictors of policy preferences to protect public health

Descriptive statistics showing the breakdowns for policy preferences to protect public health for each of the predictor variables included in the models for the five key Blue Growth areas are presented in Table 1 (the remaining five activities are presented in Table S2).

Regression outcomes for the five key activities are presented in Table 2 (with the remaining five activities regression outcomes presented in Table S3). In terms of attitudes towards these activities, broadly speaking, the more people thought the five key Blue Growth areas benefitted the economy, the more they wanted policy intervention to protect public health. This was true of all five activities: aquaculture (β = 0.10, 95% CIs = 0.08, 0.12); offshore wind farms (β = 0.10, 95% CIs = 0.08, 0.12); deep-sea mineral extraction (β = 0.09, 95% CIs = 0.08, 0.11); medicines from marine organisms (β = 0.12, 95% CIs = 0.10, 0.14); and recreational visits (β = 0.07, 95% CIs = 0.04, 0.10). This may indicate a concern about the potential negative side-effects of growth for public health and public desire for protective actions.

By contrast, the more people thought the activities would have positive impacts on the environment, the less policy intervention they tended to want to protect public health, or to put it another way, the more activities were perceived as being negative for the environment, the more intervention was wanted. This was true for aquaculture (β = -0.04, 95% CIs = -0.06, -0.02); offshore wind farms (β = -0.04, 95% CIs = -0.06, -0.02); deep-sea mineral extraction (β = -0.12, 95% CIs = -0.14, -0.09) and medicines from marine organisms (β = -0.03, 95% CIs = -0.05, -0.01). The reverse was seen for recreational visits, however, with those perceiving visits as good for the environment having stronger preferences for policy intervention to protect public health (β = 0.11, 95% CIs = 0.09, 0.14).

Finally, in terms of health-related attitudes, a similar association as for environmental attitudes was found for recreational visits (β = -0.14, 95% CIs = -0.16, -0.11) and deep-sea mineral extraction (β = -0.04, 95% CIs = -0.07, -0.02), with those who perceived these activities as being good for health wanting less policy intervention (or perceived as bad for health wanting more intervention). For aquaculture, offshore wind farms and producing medicines from marine organisms there was no association. Intriguingly, attitudes in terms of the impacts of activities on the economy and the environment were often stronger predictors of policy preferences for protecting public health, than health-related attitudes.

Table 1
Weighted descriptive statistics for each of the variables included in the models predicting people's desire for policy intervention to protect public health and wellbeing from the five key Blue Growth maritime activities.

	Aquaculture		Offshore wind farms		Deep-sea mineral extraction		Producing medicines from marine organisms		Recreational visits	
	N	r / Mean (SD)	N	r / Mean (SD)	N	r / Mean (SD)	N	r / Mean (SD)	N	r / Mean (SD)
Attitudes (−3 to + 3)										
Economic	11982.91	0.08	11674.51	0.08	11571.67	0.06	11433.57	0.12	12353.91	0.06
Environmental	11919.59	−0.02	11571.26	0.00	11680.63	−0.14	11398.72	0.04	12377.93	0.08
Health	11957.14	−0.01	11588.60	0.02	11564.45	−0.11	11497.63	0.08	12394.14	−0.06
Distance to coast (ref = >50 km)										
<1 km	1164.12	4.38 (1.57)	1151.67	4.38 (1.70)	1135.20	4.59 (1.74)	1131.00	4.26 (1.67)	1172.44	3.24 (1.98)
1–5 km	1316.24	4.29 (1.49)	1289.16	4.39 (1.61)	1289.83	4.62 (1.67)	1274.95	4.24 (1.60)	1337.17	3.33 (1.89)
5–20 km	1631.62	4.28 (1.46)	1600.19	4.32 (1.57)	1610.50	4.59 (1.64)	1587.32	4.29 (1.52)	1656.09	3.37 (1.83)
20–50 km	1260.21	4.18 (1.50)	1243.01	4.28 (1.64)	1240.94	4.45 (1.73)	1215.22	4.20 (1.58)	1271.90	3.20 (1.87)
>50 km	6865.25	4.04 (1.57)	6746.92	4.17 (1.65)	6790.45	4.46 (1.71)	6741.11	4.14 (1.61)	6993.44	3.29 (1.82)
Missing	72.77	4.16 (1.84)	66.75	4.07 (1.72)	68.84	4.09 (1.93)	68.98	3.81 (1.72)	74.63	3.08 (2.02)
Working in the marine sector (ref = No)										
No	10645.56	4.15 (1.54)	10455.61	4.25 (1.64)	10490.47	4.54 (1.69)	10386.31	4.19 (1.60)	10806.64	3.24 (1.85)
Yes	1213.37	4.15 (1.58)	1195.82	4.23 (1.65)	1198.40	4.34 (1.74)	1190.03	4.17 (1.63)	1236.42	3.57 (1.85)
Missing	451.28	4.01 (1.62)	446.27	4.11 (1.73)	446.89	3.98 (1.86)	442.26	4.10 (1.69)	462.60	3.68 (1.69)
N coastal recreational activities										
N activities	12270.70	0.03	12060.92	0.06	12099.93	0.05	11981.03	0.03	12467.10	0.00
Political view (ref = Left)										
Left	2766.46	4.25 (1.55)	2723.40	4.31 (1.70)	2740.80	4.61 (1.79)	2700.45	4.27 (1.63)	2797.33	3.24 (1.88)
Centre	4863.98	4.14 (1.50)	4796.97	4.26 (1.57)	4804.32	4.54 (1.62)	4754.34	4.17 (1.54)	4936.58	3.28 (1.80)
Right	3053.86	4.07 (1.56)	3004.50	4.19 (1.64)	3008.77	4.41 (1.69)	3001.80	4.12 (1.62)	3077.19	3.30 (1.88)
Missing	1625.92	4.16 (1.63)	1572.84	4.20 (1.76)	1581.88	4.37 (1.80)	1562.00	4.21 (1.70)	1694.56	3.37 (1.88)
Gender (ref = Male)										
Male	6072.20	4.05 (1.55)	6034.64	4.18 (1.65)	6018.63	4.45 (1.72)	5945.91	4.08 (1.59)	6138.17	3.23 (1.82)
Female	6238.02	4.24 (1.54)	6063.07	4.31 (1.63)	6117.14	4.55 (1.69)	6072.67	4.28 (1.61)	6367.50	3.34 (1.88)
Age										
Age	12310.21	0.08	12097.71	0.08	12135.77	0.08	12018.59	0.04	12505.66	0.02
Educational attainment (ref = No degree)										
No degree	6217.91	4.08 (1.58)	6068.33	4.17 (1.67)	6082.77	4.36 (1.79)	6057.04	4.14 (1.63)	6350.73	3.38 (1.87)
Degree	6037.47	4.22 (1.51)	5975.10	4.32 (1.61)	5997.65	4.65 (1.60)	5907.40	4.24 (1.57)	6097.30	3.20 (1.82)
Missing	54.84	4.04 (1.58)	54.28	3.96 (1.79)	55.35	4.06 (1.75)	54.15	3.77 (1.88)	57.63	3.23 (1.95)
Income category (ref = Middle income)										
Low income	2591.89	4.19 (1.59)	2545.04	4.24 (1.70)	2546.56	4.41 (1.81)	2535.18	4.20 (1.64)	2659.67	3.36 (1.89)
Middle income	4206.55	4.15 (1.53)	4127.06	4.26 (1.63)	4125.24	4.51 (1.70)	4096.32	4.19 (1.59)	4244.67	3.33 (1.84)
High income	3951.27	4.14 (1.53)	3883.36	4.26 (1.61)	3922.09	4.59 (1.63)	3880.60	4.20 (1.58)	3989.98	3.27 (1.83)
Non-reported income	1560.49	4.09 (1.53)	1542.25	4.17 (1.65)	1541.87	4.40 (1.72)	1506.49	4.10 (1.65)	1611.35	3.11 (1.84)
Employment status (ref = In employment)										
Employed	6697.42	4.15 (1.51)	6593.76	4.23 (1.60)	6623.29	4.52 (1.65)	6546.33	4.20 (1.55)	6794.12	3.32 (1.81)
Unemployed	2309.48	4.18 (1.59)	2263.71	4.31 (1.68)	2275.86	4.44 (1.80)	2254.76	4.21 (1.65)	2358.17	3.35 (1.88)
Student	709.41	3.76 (1.62)	693.30	3.87 (1.68)	704.76	4.23 (1.66)	690.96	4.00 (1.55)	712.43	2.91 (1.80)
Retired	2432.05	4.22 (1.57)	2383.07	4.36 (1.67)	2370.15	4.61 (1.76)	2359.90	4.20 (1.70)	2468.24	3.23 (1.94)
Missing	161.85	4.17 (1.60)	163.87	3.91 (1.81)	161.71	4.29 (1.72)	166.64	4.03 (1.73)	172.71	3.50 (1.81)
Country										
Belgium	894.86	4.09 (1.49)	886.79	4.19 (1.63)	858.32	4.25 (1.62)	861.01	4.00 (1.55)	908.82	3.34 (1.70)
Bulgaria	908.21	4.35 (1.64)	889.58	4.59 (1.61)	908.22	4.82 (1.65)	918.85	4.53 (1.63)	924.80	3.63 (1.92)
Czech Republic	895.41	3.67 (1.58)	856.67	3.67 (1.62)	893.03	4.27 (1.71)	883.49	3.80 (1.62)	915.99	3.21 (1.78)
France	925.57	4.27 (1.61)	898.14	4.45 (1.63)	900.30	4.53 (1.89)	900.73	4.20 (1.69)	930.90	3.35 (1.84)
Germany	889.34	3.91 (1.51)	868.35	4.02 (1.69)	877.71	4.33 (1.80)	876.70	3.93 (1.59)	911.80	3.03 (1.81)
Greece	619.88	4.56 (1.44)	603.67	4.70 (1.45)	612.88	5.01 (1.46)	611.14	4.64 (1.43)	624.63	3.34 (1.98)
Italy	943.66	4.12 (1.52)	911.90	4.19 (1.68)	935.82	4.07 (2.04)	905.93	4.06 (1.67)	961.39	4.02 (1.72)
Netherlands	884.88	3.85 (1.43)	889.16	4.02 (1.55)	859.74	4.18 (1.48)	849.15	4.02 (1.47)	899.45	3.33 (1.63)
Norway	850.90	4.35 (1.47)	838.26	4.22 (1.60)	819.49	4.35 (1.57)	819.18	3.96 (1.60)	859.06	2.54 (1.86)
Poland	928.78	3.76 (1.59)	926.89	4.14 (1.54)	926.58	4.27 (1.63)	929.35	3.98 (1.58)	941.97	3.27 (1.86)
Portugal	785.51	4.25 (1.53)	742.12	4.38 (1.61)	767.51	4.50 (1.86)	751.97	4.41 (1.56)	787.60	3.69 (1.69)
Republic of Ireland	942.11	4.39 (1.45)	930.17	4.20 (1.69)	928.15	4.85 (1.43)	910.89	4.31 (1.52)	955.01	3.07 (1.88)
Spain	947.45	4.40 (1.47)	948.63	4.69 (1.52)	946.95	4.73 (1.73)	934.68	4.56 (1.54)	961.29	3.74 (1.75)
United Kingdom	893.65	4.22 (1.57)	907.37	4.10 (1.80)	901.06	4.97 (1.45)	865.53	4.30 (1.64)	922.94	2.45 (1.84)

Note: Descriptive statistics are weighted using scaled survey weights, which take into account respondent's country of origin, region, age and gender. N refers to the weighted sample size, once missing values have been removed. For continuous variables (attitudes, recreational visits and age) the correlation coefficient (r) is shown. For categorical variables, the mean and standard deviation (SD) is shown. A similar table for the other five maritime activities can be found in Table S2.

Table 2
Predictors of policy preferences to protect public health from the five key maritime activities.

	Aquaculture		Offshore wind farms		Deep-sea mineral extraction		Producing medicines from marine organisms		Recreational visits	
	ß	[95% CIs]	ß	[95% CIs]	ß	[95% CIs]	ß	[95% CIs]	ß	[95% CIs]
Intercept										
Intercept	3.54***	[3.35, 3.73]	3.53***	[3.33, 3.74]	3.64***	[3.42, 3.86]	3.77***	[3.57, 3.98]	3.32***	[3.05, 3.58]
Attitudes (−3 to + 3)										
Economic	0.10***	[0.08, 0.12]	0.10***	[0.08, 0.12]	0.09***	[0.08, 0.11]	0.12***	[0.10, 0.14]	0.07***	[0.04, 0.10]
Environmental	−0.04***	[−0.06, −0.02]	−0.04***	[−0.06, −0.02]	−0.12***	[−0.14, −0.09]	−0.03**	[−0.05, −0.01]	0.11***	[0.09, 0.14]
Health	−0.01	[−0.03, 0.01]	0.00	[−0.02, 0.03]	−0.04***	[−0.07, −0.02]	0.02	[0.00, 0.05]	−0.14***	[−0.16, −0.11]
Distance to coast (ref = >50 km)										
<1 km	0.07	[−0.03, 0.18]	0.06	[−0.05, 0.18]	−0.01	[−0.13, 0.11]	−0.03	[−0.14, 0.09]	0.09	[−0.03, 0.21]
1–5 km	0.04	[−0.06, 0.14]	0.13*	[0.02, 0.23]	0.05	[−0.06, 0.16]	−0.06	[−0.17, 0.05]	0.12*	[0.00, 0.23]
5–20 km	0.09	[−0.01, 0.18]	0.11*	[0.01, 0.21]	0.09	[−0.01, 0.19]	0.02	[−0.08, 0.12]	0.10	[−0.01, 0.20]
20–50 km	0.03	[−0.07, 0.13]	0.08	[−0.02, 0.19]	−0.07	[−0.18, 0.04]	−0.04	[−0.15, 0.06]	−0.06	[−0.17, 0.05]
Missing	−0.07	[−0.44, 0.3]	−0.20	[−0.62, 0.21]	−0.30	[−0.73, 0.13]	−0.42*	[−0.81, −0.02]	−0.28	[−0.70, 0.14]
Working in the marine sector (ref = No)										
Yes	0.06	[−0.03, 0.15]	−0.01	[−0.11, 0.09]	−0.06	[−0.16, 0.04]	0.01	[−0.09, 0.11]	0.24***	[0.13, 0.35]
Missing	−0.01	[−0.15, 0.14]	−0.13	[−0.29, 0.03]	−0.33***	[−0.49, −0.16]	0.01	[−0.15, 0.17]	0.32***	[0.15, 0.49]
N coastal recreation activities										
N activities	0.02***	[0.01, 0.03]	0.03***	[0.02, 0.04]	0.03***	[0.01, 0.04]	0.01*	[0.00, 0.03]	−0.01	[−0.02, 0.00]
Political orientation (ref = Left)										
Right	−0.12**	[−0.2, −0.04]	−0.07	[−0.15, 0.02]	−0.05	[−0.14, 0.04]	−0.09*	[−0.18, −0.01]	0.02	[−0.07, 0.12]
Centre	−0.04	[−0.12, 0.03]	0.00	[−0.07, 0.08]	−0.01	[−0.09, 0.07]	−0.07	[−0.15, 0.01]	0.04	[−0.04, 0.12]
Missing	0.00	[−0.09, 0.10]	−0.04	[−0.14, 0.07]	−0.11	[−0.22, 0.00]	−0.04	[−0.15, 0.07]	0.04	[−0.07, 0.15]
Gender (ref = Male)										
Female	0.14***	[0.09, 0.19]	0.09**	[0.03, 0.15]	0.06	[0, 0.12]	0.19***	[0.13, 0.25]	0.13***	[0.07, 0.20]
Age										
Age	0.01***	[0.01, 0.01]	0.01***	[0.01, 0.01]	0.01***	[0.01, 0.01]	0.00**	[0.00, 0.01]	0.00	[-0.00, 0.00]
Educational attainment (ref = No degree)										
Degree	0.04	[−0.02, 0.09]	0.06*	[0, 0.13]	0.15***	[0.09, 0.22]	−0.02	[−0.08, 0.04]	−0.10**	[−0.17, −0.03]
Missing	0.00	[−0.43, 0.42]	−0.13	[−0.6, 0.34]	−0.25	[−0.74, 0.23]	−0.42	[−0.89, 0.04]	0.02	[−0.48, 0.51]
Income category (ref = Middle income)										
Low income	0.03	[−0.04, 0.11]	−0.02	[−0.10, 0.07]	−0.07	[−0.15, 0.02]	0.04	[−0.04, 0.13]	0.03	[−0.06, 0.12]
High income	0.01	[−0.06, 0.08]	0.00	[−0.08, 0.07]	0.00	[−0.08, 0.07]	−0.01	[−0.09, 0.06]	−0.08*	[−0.16, 0.00]
Non-reported income	−0.03	[−0.13, 0.06]	0.03	[−0.07, 0.13]	−0.05	[−0.16, 0.05]	−0.05	[−0.15, 0.05]	−0.17**	[−0.27, −0.06]
Employment status (ref = In employment)										
Unemployed	−0.05	[−0.12, 0.03]	0.02	[−0.06, 0.10]	−0.06	[−0.15, 0.02]	−0.06	[−0.14, 0.02]	−0.08	[−0.17, 0.01]
Student	−0.28***	[−0.41, −0.15]	−0.20**	[−0.34, −0.06]	−0.07	[−0.21, 0.07]	−0.15*	[−0.28, −0.01]	−0.34***	[−0.48, −0.19]
Retired	−0.08	[−0.17, 0.01]	0.00	[−0.10, 0.10]	−0.04	[−0.14, 0.06]	−0.07	[−0.17, 0.03]	−0.12*	[−0.22, −0.02]
Missing	0.04	[−0.21, 0.29]	−0.20	[−0.47, 0.08]	0.03	[−0.25, 0.31]	0.07	[−0.19, 0.34]	0.12	[−0.16, 0.41]
Model info										
N	12,178		11,729		11,674		11,421		12,848	
N (Country)	14		14		14		14		14	
AIC	45052.54		44900.05		45311.84		43216.77		51882.43	
BIC	45259.95		45106.41		45518.06		43422.37		52091.33	
R^2 (fixed)	0.02		0.02		0.05		0.02		0.02	
R^2 (total)	0.04		0.04		0.07		0.05		0.07	

Notes: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. A table showing the regression outputs for the other five activities can be found in Table S3.

Due to space constraints the socio-demographic predictors of policy preferences are summarised here with full details provided in Table 2. First, we explored variables related to personal marine contact (proximity, employment, recreational activities). Generally speaking, coastal proximity was unrelated to preferences for health-related policies. Of the 10 maritime activities we explored, living closer to the coast was only associated with stronger policy preferences for offshore wind farms and general public recreational visits to the coast, but since these were both only marginally significant, we do not want to over-interpret these findings, especially given the large sample size. Those who lived in a household where at least one person worked in the marine sector also wanted (this time significantly) more intervention to protect public health from general public recreational visits, but this was not seen for any other activity. In terms of the number of coastal recreation activities engaged in personally, the more people participated, the higher their policy intervention preferences for aquaculture, offshore wind farms, deep-sea mineral extraction and medicines from marine organisms. These associations were very small; and intriguingly there was no

association with recreational visits of the public more generally. Consistent with previous research, people with more right-wing political leanings tended to want less policy intervention, but this was only significant for aquaculture and medicines from marine organisms. Also consistent with previous findings regarding policy interventions to protect public health in general, women tended to want more intervention than men for all maritime activities, except for deep-sea mineral extraction. Older respondents also wanted more policy intervention for aquaculture, offshore wind farms, deep-sea mineral extraction, and medicines from marine organisms.

People with (versus without) a degree-level education had higher policy preferences for offshore wind farms and deep-sea mineral extraction, but lower preferences for recreational visits. However, current students wanted less policy intervention than employed people for aquaculture, offshore wind farms, medicines from marine organisms, and recreational visits. Retired people wanted less policy intervention to protect public health from recreational visits. Those with a high income wanted less health-related policy for recreational visits, compared to those with a middle income. The amount of variance explained was low, ranging from 4% (aquaculture and offshore wind farms) to 7% (deep-sea mineral extraction and recreational visits), once country-level random effects were included.

For the ordinal models, we found that 82.4% of results were consistent across both sets of models. Other studies have also reported linear and ordinal analysis producing essentially the same outcomes, with linear approaches also being far easier to interpret (Ferrer-i-Carbonell and Frijters, 2004). The biggest discrepancies were observed for political orientation, with those with more central views wanting significantly less health-related policy for aquaculture, deep-sea mineral extraction and producing medicines, and right-leaning individuals wanting less policy for offshore wind farms and deep-sea mineral extraction. Other variables with discrepancies were distance living from the coast, coastal recreational activities, gender, income and employment status (see Table S4).

3.4. RQ4: Country variation in policy preferences to protect public health?

3.4.1. Country variation in mean policy preferences

Fig. 2 presents the country-level random intercept terms across the five key Blue Growth maritime activities (fully adjusted models). This shows how each country varies from the overall model intercept for policy preferences for each activity. There is considerable variation in the preference for policy interventions between countries for all activities, with the largest variance seen for recreational visits (Fig. 2e).

Respondents from Greece, Spain and Bulgaria (Mediterranean and Black Sea countries) tended to want relatively high levels of policy intervention compared to the sample average, whereas, respondents in Germany, the Netherlands and Poland (North and Baltic Sea countries) tended to want less intervention. Norwegian respondents also showed relatively low preferences for policies to protect public health with the exception of high preference for aquaculture, perhaps reflecting the relative importance (and greater public awareness) of this activity in Norway. For other countries, such as the UK, the ranking of policy preferences varied quite widely as a function of activity. For instance, the UK is ranked third for high policy preferences for deep-sea mineral extraction, but at the bottom for recreational visits. Italian respondents showed the opposite pattern, ranking top for recreational visits and bottom for deep-sea mineral extraction, in terms of country means.

3.4.2. Country variation in associations between key predictor variables and policy preferences

Based on the outcomes of the fully adjusted models (Table 2), we further investigated country-level variation for predictors that

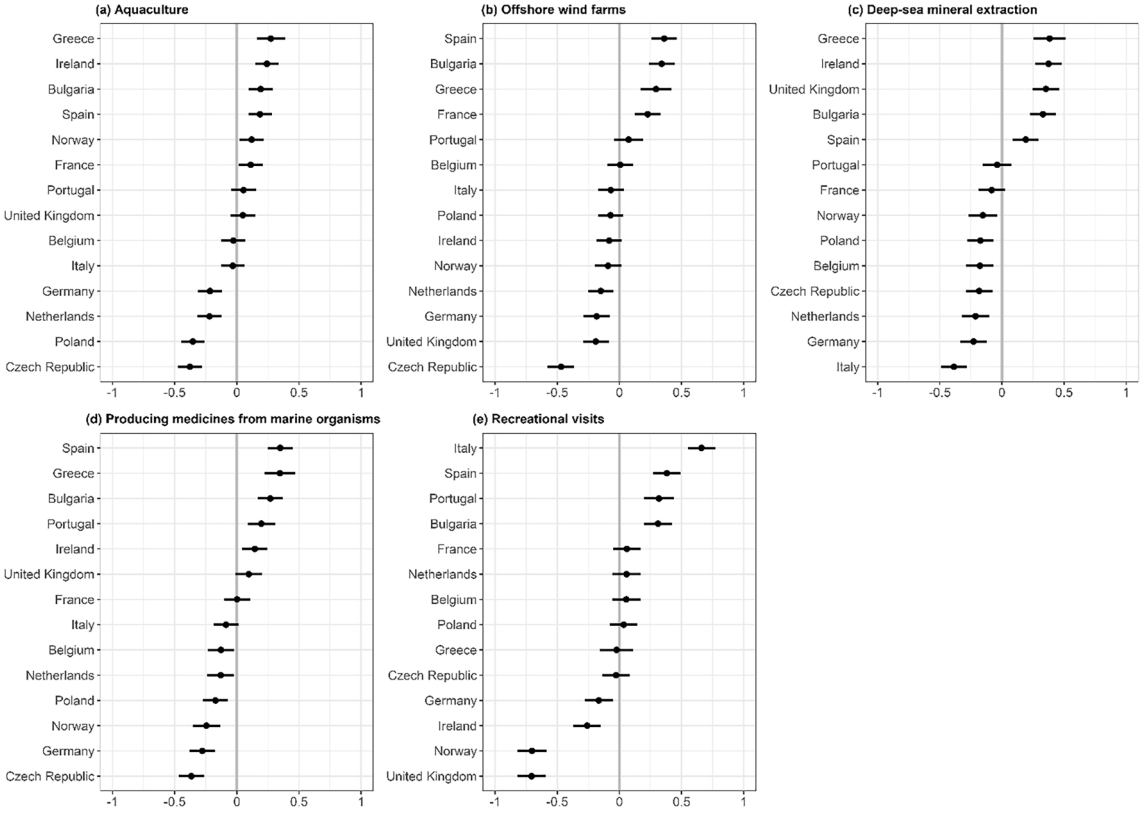

Fig. 2. Country-level intercepts showing preferences for policies to protect public health from the five key Blue Growth strategy areas: a) aquaculture, b) offshore wind farms, c) deep-sea mineral extraction, d) producing medicines from marine organisms and e) recreational visits; with standard error bars shown. Country-level intercepts for the remaining five maritime activities can be found in Figure S2.

consistently emerged as significant across activities, namely economic, environmental and health-related attitudes, as well as age and gender, using random slopes as well as random intercepts for country. Table 3 presents the country-level variances (σ^2) in the relationships between these five predictors and policy preferences for the five key maritime activities.

To understand the impact of adding the random slope term to the fully adjusted models, we compared R^2 values and used Wald's F-Test to compare between the two models. We found that total R^2 values ranged from 0.04 to 0.13 for the slope models (versus 0.04–0.07 for the random intercept models). Using Wald's F-Test we found that the slope models were significantly better at explaining the data compared to the random intercept models for the environmental and health attitude slopes for aquaculture, offshore wind farms, producing medicines and recreational visits. The health attitude slope model was also better for deep-sea mineral extraction and the economic attitudes slope model was better for offshore wind farms.

The relationships between policy preferences and all three attitudinal components vary significantly across countries for all five activities. Similarly, the relationships between policy preferences and gender also varied across countries, however age showed no significance. These variances in the relationships are presented graphically in Fig. 3 where the predicted linear relationship is plotted for each country separately, with the overall predicted mean line also shown.

The lack of cross-country variation in the relationship between age and policy preferences for aquaculture can be seen in Fig. 3 panels 1-5d where the lines for each country are essentially parallel and relatively close together. Most of the remaining panels show greater variation in the lines, although a range of different patterns emerged. One pattern, visible in several panels, are countries clustering at the lower ends of the predictor variable and fanning out at the higher ends of the predictor variable. For example panel 3d suggests that for deep-sea mineral extraction, young adults have similar policy preferences across countries but that older adults vary across country. The opposite pattern is also visible where clustering occurs at higher values of the predictor and the fanning out takes place at the lower levels. For instance panel 3a, which here means that policy preferences are high in all countries when the economic impacts of deep-sea mineral extraction are thought to be positive, but variation occurs across countries when this activity is thought to be bad for the economy.

In other panels, it seems to be just one or two countries that show a different relationship than the majority, or stronger relationships than in other countries. For instance, in panel 5c, Italy shows a stronger positive association between health-related attitudes and policy preferences for medicines from marine organisms than any other country. In fact, Italy showed a more pronounced upward trend in 11 out of the 25 Blue Growth models, compared to the slopes of other countries (see Table S6).

4. Discussion

4.1. Summary of results

The current study explored public perceptions across 14 European countries of 10 key maritime activities, with a specific focus on five areas associated with the EU Blue Growth Strategy (European Commission, 2012): aquaculture, ocean energy (e.g. offshore wind farms), sea-bed mining (e.g. deep-sea mineral extraction), medicines from marine organisms (e.g. medicines from marine organisms), and coastal tourism (e.g. recreational visits). Consistent with the aims of Blue Growth, the respondents on average thought that all ten activities were good for the economy in absolute terms. Moreover, the respondents rated coastal tourism (recreational visits) as the most important activity for the economy, consistent with the fact that in nine out of our 14 countries, tourism is the largest maritime employer and in eight countries provides the highest gross value added (GVA) (European Commission, 2018).

By contrast, the respondents saw offshore oil/gas mining as the second least important activity for the economy, despite the fact that it contributes $22.8 billion to the EU economy (Scholaert et al., 2020). In part this may reflect a difference in terms of scope, with respondents thinking about the benefits to *local (or national)* economies from local coastal tourism, as opposed to the economic benefits that offshore oil/gas mining have at a European economy level, where only a few countries/regions directly benefit.

Despite widespread appreciation of the potential benefits to the economy of these activities, the respondents also believed that several of them have negative effects on the environment (offshore oil/gas mining, deep-sea mineral extraction, shipping, commercial fishing and holiday cruises) and public health (offshore oil/gas mining, deep-sea mineral extraction and shipping), reflecting an appreciation of trade-offs. Nevertheless, consistent with the affect heuristic (Slovic et al., 2007), the notion that perceptions of both risk and benefit are influenced by people's affective disposition towards a technology and need for cognitive consistency, the five activities which were seen as most beneficial for the economy (aquaculture, offshore wind farms, medicines, recreational visits and water sports) were also seen as the top five most beneficial for the environment and for public health. At the same time, offshore oil/gas mining, deep-sea mineral extraction, shipping, commercial fishing and holiday cruises were consistently ranked in the bottom five activities for all three domains.

Preferences for greater policy intervention to protect public health from the 10 maritime activities tended to be positively associated with the perceived economic benefits and negatively associated with perceived potential environmental benefits. Again, the relationship with economic benefits supports the notion that the public is able to understand potential trade-offs, seeing that economic rewards may come at the cost of endangering public health unless action to mitigate these consequences is taken.

By contrast, the greater the benefits to the environment, the less desire for public health policies. This suggests that the public tends to believe there is a link between environmental quality and public health: if an activity benefits the environment, there is no need to intervene to

Table 3
Cross-country variance for the amount of health-related policy intervention wanted for each of the five key Blue Growth areas for attitudes, as well as two key socio-demographic variables. Significance levels were calculated using the standard error and variance. Slopes are plotted in Fig. 3.

	Aquaculture	Offshore wind farms	Deep-sea mineral extraction	Producing medicines from marine organisms	Recreational visits
	σ^2 (SE)	σ^2 (SE)	σ^2 (SE)	σ^2 (SE)	σ^2 (SE)
Economic attitude	0.004 (0.001)***	0.009 (0.001)***	0.002 (0.000)***	0.003 (0.001)***	0.004 (0.001)***
Environmental attitude	0.009 (0.001)***	0.011 (0.001)***	0.004 (0.001)***	0.005 (0.001)***	0.009 (0.001)***
Health attitude	0.009 (0.001)***	0.012 (0.001)***	0.005 (0.001)***	0.004 (0.001)***	0.01 (0.001)***
Age	0.000 (0.000)n.s.	0.000 (0.000)n.s.	0.000 (0.000)n.s.	0.000 (0.000)n.s.	0.000 (0.000)n.s.
Gender	0.001 (0.000)***	0.008 (0.001)***	0.009 (0.001)***	0.010 (0.001)***	0.016 (0.001)***

Notes: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. Table showing the slope variance for the other five activities can be found in Table S5

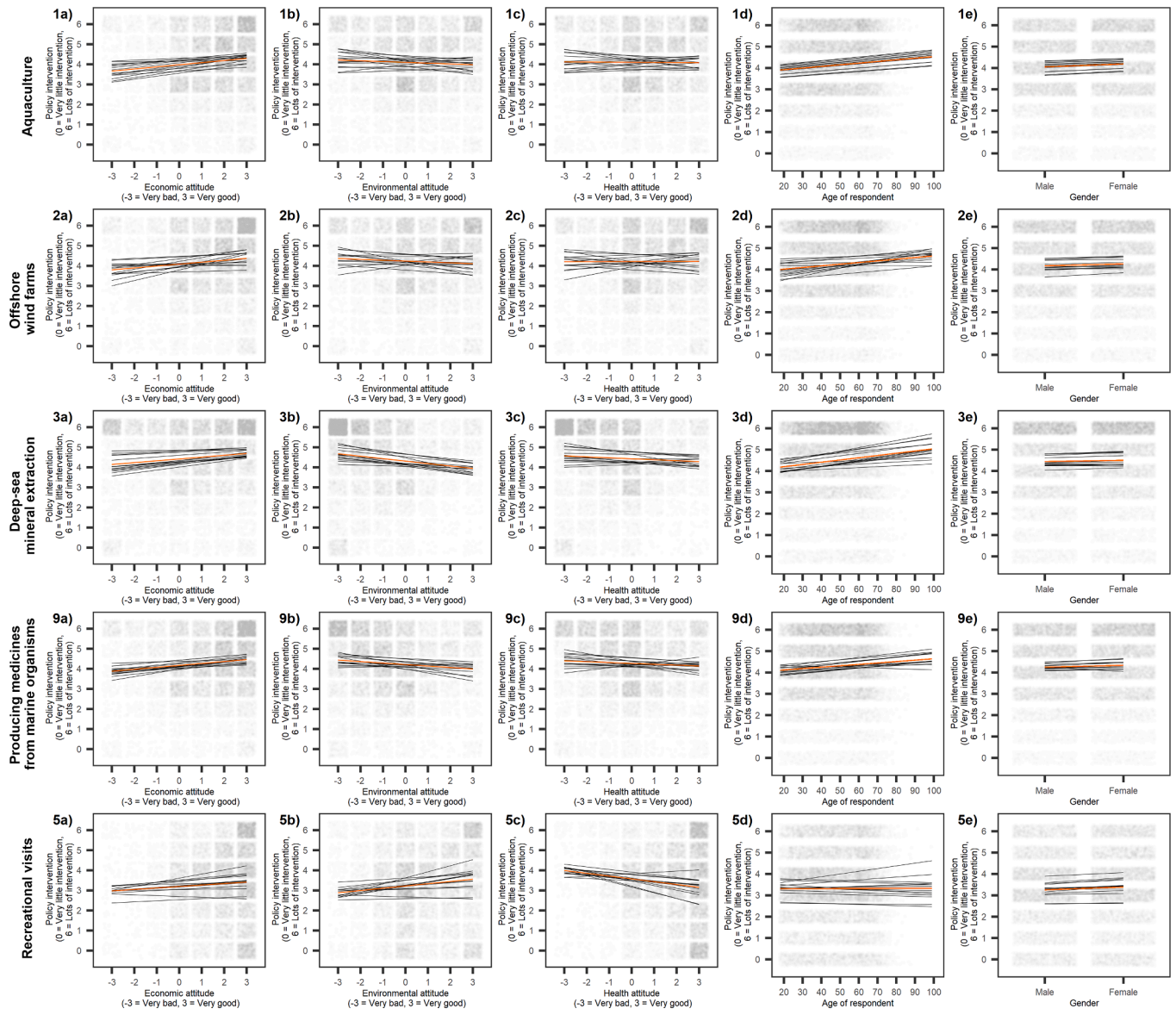

Fig. 3. Cross-country slopes for health-related policy intervention desired across the five key Blue Growth strategy activities: 1) aquaculture, 2) offshore wind farms, 3) deep-sea mineral extraction, 4) producing medicines from marine organisms, and 5) recreational visits in relation to attitudes towards the: (a) economy, (b) environment and (c) public health and wellbeing, as well as two key socio-demographic variables: (d) age and (e) gender. Slopes for each of the 14 countries (black) as well as the mean slopes (orange) are shown. Raw data are shown as a jitter plot behind the slopes. Slope values for all 14 countries, for each of the plots, are shown in Table S6 and the cross-country slopes for the remaining five maritime activities can be found in Figure S3. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

protect public health because it is not under threat. By contrast, if an activity is seen to threaten the environment, policy intervention is preferred to protect public health from environmental degradation. This possible intuitive understanding of the link between ocean and human health, backed up by a growing body of scientific evidence (Whitmee et al., 2015), could be crucial in motivating people to protect marine ecosystems (Depledge et al., 2019; Fleming et al., 2019).

However, we recognise that more work is needed to explore this possibility further due to the difficulty in unpacking more complex and nuanced associations in people's minds using cross-sectional surveys. For instance, Boase et al., (2019) also used in-depth qualitative interviews to investigate the public's understanding of the links between the environment and human health in the context of aquaculture in the UK, revealing quite sophisticated thinking among some respondents. One respondent, for example, explicitly connected fish health, human health (from eating non-diseased fish) and damage to the environment from the use of unprocessed pharmaceuticals in the aquaculture process: "*I don't think it's sustainable environmentally, because they're using more and more drugs to stop them getting diseases*" (Boase et al., 2019, pg. 3). Further qualitative work of this kind would help us better understand the complex intuitive 'mental models' (Boase et al., 2017) the public has about the links between marine environments and human health, and thus potentially improve understanding of certain policy preferences.

Surprisingly, the associations between beliefs about the public health implications of maritime activities and the preferences for policy interventions to protect public health were mixed and generally weak across the five Blue Growth activities. Analyses exploring the associations without covariates (not presented) found similar results, so the findings are not due to any relationships being explained by socio-demographic issues. The exception was for general public 'recreational visits', where the association between health attitudes and health-related policy was negative and relatively strong (compared to other

predictors). In other words, the more respondents perceived visiting the coast for recreation was good for public health, the *less* regulation they wanted. Again, more in-depth qualitative work is needed to unpack this finding but it did not seem to reflect a personal reluctance to be regulated, since there was no association between the number of marine recreational activities respondents engaged in personally and health-related policies (B = -0.01; Table 2). We suspect instead that it may reflect a general wariness for regulation where health benefits are believed to already occur, and/or potentially a lack of understanding of policy interventions, such as the EU's Bathing Waters directive (European Union, 2006), which already tries to protect health for recreational marine water users.

For instance, all designated bathing water sites across the EU now need to show results of a rolling average of water quality in terms of faecal indicators (e.g. *E coli*) on signs at the main public entrances to the site (European Commission, 2011). Although experimental research suggests that people are potentially sensitive to signage indicating improving or worsening bathing water quality (Börger et al., 2021), there has been little direct observation of whether people actually see, understand or react to these signs in practice at real bathing water sites. Further research into public understanding of, and potentially greater awareness raising exercises about, existing efforts to protect the health of recreational users of marine settings seems warranted. For instance, the results of the current survey are unable to tell us whether people see such measures as protecting health or merely restricting freedom of choice, despite the signage being advisory. More qualitative work could begin to aid our understanding of these somewhat surprising results.

Supporting previous research in other domains (e.g. climate change, Poortinga et al., 2019), a range of contact and socio-demographic variables were significant predictors of preferences for policy interventions to protect public health. We also found that at least one of the three marine contact variables (home proximity, employment, personal recreation) was a significant predictor of health-related policy preferences across all activities. For instance, those who lived within 1–20 km (but not <1 km) of the coast had higher policy preference for offshore wind farms than those who lived far inland (>50 km). This is generally consistent with findings that offshore wind farms are often met with objections from local communities due to aesthetic and place-based concerns (Haggett, 2011). That the preferences of those living right at the coast, and thus those presumably most likely to see the wind farms were no different from those far inland is somewhat surprising and may reflect either greater awareness of their benefit (e.g. to the local economy) or adaptation and acceptance among those already living near such farms to their presence. As noted elsewhere, further and perhaps more qualitative work is needed to explore why people at different proximities from the coast may vary on such issues in potentially counter-intuitive ways.

Those who worked in, or lived with someone who worked in, a marine related industry had greater policy preferences for recreational visits. Although we were unable (due to low Ns) to explore this result for specific occupations, it may reflect the fact that people who work in the marine sector are either more aware of the negative effects of seasonally concentrated coastal tourism for both the environment (Davenport and Davenport, 2006) and for the health of coastal residents (Fleming et al., 2006), and/or see coastal tourism as conflicting with other maritime activities, such as boating near aquaculture or offshore wind farms. Finally, connection to the marine environment through participating in coastal recreation led to increased health-related policy support for aquaculture, offshore wind farms and deep-sea mineral extraction. These are all activities which could potentially reduce the quality of the marine environment, which has negative impacts on recreational visits (Börger et al., 2021).

Consistent with previous findings for climate change (Poortinga et al., 2019), we found that individuals on the political right had lower policy preferences for aquaculture; and that women wanted more policy intervention for all maritime activities compared to men. This latter finding contrasts with earlier research which found that gender was not related to concern for ocean health (Potts et al., 2016), although here we focused on human, rather than ocean, health. Consistent with Potts et al.'s (2016) findings, however, older individuals also tended to have greater policy preferences for the majority of maritime activities.

Individuals educated to degree level had greater policy preferences for deep-sea mineral extraction, but less policy preference for recreational activities, than those without a degree. Current students had lower policy preferences for all maritime activities except deep-sea mineral extraction, than those in employment. The contrast between the strength of policy preferences between those educated to degree level and current students could relate to the finding that older people tended to want more policy. Poortinga et al., (2019) found that younger people are more concerned about climate change compared to older individuals, and this could be reflected in our results where current students believe that through reducing the level of policy it could make it easier for maritime projects such as offshore wind farms to go ahead, thus enhancing the amount of renewable energy produced.

Retired individuals also had lower policy preferences for recreational visits. Coastal recreation, and living by the sea, have numerous benefits for individuals health and wellbeing (White et al., 2020), particularly for older people (Coleman and Kearns, 2015). Therefore, it could be that these individuals perceive policy as something that would impact upon their ability to interact with the marine environment through recreation. Finally, there were no interpretable relationships between household income and policy preferences suggesting that income *per se* is not a predictor of policy preferences in this domain.

Perhaps the most important results were the consistent between-country differences, both in terms of the average levels of policy preferences for the five key activities across countries (Fig. 2), but also the patterns of association between countries (Fig. 3). We should be extremely careful in talking about a European public perception of these issues, when our results demonstrate significant differences across European populations. Certain countries wanted consistently more policy intervention to protect public health (e.g. Bulgaria, Spain and Greece) than others (e.g. Germany, the Netherlands and the Czech Republic).

To some extent this may reflect the relative importance of these activities in those respective countries. For instance, Spain and Greece employ the highest and fourth highest number of people in the aquaculture industry, respectively, of our 14 countries (European Commission, 2020a). Thus a greater awareness of aquaculture issues, and the need to protect public health, may have influenced their preferences. Country differences appeared to be most pronounced for aquaculture and offshore wind, when compared to their economic, environmental and health attitudes. Without wishing to over-simplify or over-generalise, we note that the countries with the highest general policy preferences tended to be in the European South (Spain, Greece, Portugal, Bulgaria) and those with the lowest preferences tended to be in the European north (Germany, Netherlands, Norway, Poland), alongside the Czech Republic without a coast. We have no clear reason why this pattern may have emerged.

We also noted that in some cases country-level differences were far less pronounced among certain socio-demographic groups e.g. younger compared to older respondents for deep-sea mineral extraction. This would suggest that engagement on this issue at the general European level would be sufficient for younger people, but that more targeted within-country messages might be needed if older adults were the main audience. We are unsure why Italy, in particular, seemed to show a different trend from other countries in many of the associations, but again note that it is important for communicators not to assume that general patterns and associations can be generalised to specific nations. These differences are important because understanding the public's perception of issues can impact the success of projects which aim to protect the marine environment (Gelcich and O'Keeffe, 2016; Lacroix et al., 2016; Potts et al., 2016). Although we do not have space to do so in the current paper, we recognise that there are many ways in which the

country-level differences, and indeed other socio-demographic factors, could have been explored in greater detail using the current data for future papers.

4.2. Limitations

We recognise several issues and limitations with the data. First, although our sample was collected by an international polling company and was representative by age, gender and region within countries, our within-country samples were still relatively small (n's ~ 1,000). Although these samples are comparable to previous multi-country studies in the marine field (Gelcich et al., 2014; Potts et al., 2016), we do not claim responses are fully representative within the respective countries (Bouman et al. 2020). The 'jitter plots' behind the lines in Fig. 3, which show the number of people in each cell (e.g. very positive attitude and high policy preference) highlights why this is important. Specifically, most people tend to cluster at certain combinations, meaning we can have greater confidence in the responses at these levels than we can where there are relatively few people. In short, until larger samples can be ascertained at all levels of these relationships, as well as for countries beyond the 14 we were able to include here, we must remain cautious about overgeneralising our findings to the "European" public.

Second, although we explored attitudes in terms of the perceived impact of activities on economic, environmental and health-related domains, we only asked about intervention preferences for each of the activities with respect to public health. The main reason for this was space constraints within the survey, which also included several other items not explored in the current manuscript (see Davison et al., 2021). Our decision to focus on the more novel/emerging issue of health within the marine context (Depledge et al., 2019; Fleming et al., 2019; Borja et al., 2020) was therefore to compliment the extensive literature already looking at public attitudes with respect to impacts on, and policy preferences toward, the environment (e.g. Gelcich et al., 2014; Potts et al., 2016; Lotze et al., 2018). We nonetheless recognise that this means we are unable to know, for instance, whether the stronger association between perceived economic and environmental impact, compared to the health-related impact of the activities on preferences for health protecting policies might reflect a generally stronger relationship between perceived economic and environmental impact and policy preferences, regardless of policy type. Further research in the future that is able to explore all three policy domains simultaneously is needed to investigate this possibility, and could provide further insights into how policy preferences across domains relate to each other. Third, we also acknowledge that using single items for measuring attitudes and policy preferences is not as robust as using multi-item scales, which better reflect the underlying latent constructs. However, this was necessitated by the need to keep the survey short in order to collect data from a large sample, and the desire to cover a wide range of maritime activities. Future research with a more targeted approach to one or two specific issues, or that uses within-country samples only, could develop such scales in an effort to improve relationship estimates.

Finally, although the variance explained in our models was low, explanatory power was comparable to other similar studies with larger numbers of respondents (Bouman et al., 2020). Further, although many of our socio-demographic predictors showed patterns similar to previous literature, there remain many other variables beyond the set of attitudes, marine contact, and socio-demographic predictors included in our models, which account for policy preferences to protect public health from the maritime activities explored here. Perceived norms and values have been found to be particularly important for climate change related perceptions (van der Linden, 2015) and might also be important to explore in the marine domain in future research.

4.3. Implications & conclusions

These limitations notwithstanding, our results highlight several important issues. European citizens appear aware of the link between the oceans and public health, but attitudes differ widely both between countries and within countries in terms of different socio-demographic groups. Simple messaging and communication strategies are unlikely to appeal to such a heterogeneous set of citizens. It was also clear that perceptions of how policies can be utilised to protect public health and wellbeing varied across maritime activities. On the whole, policies to protect public health were supported, and this is particularly important to note with respect to aquaculture and offshore wind farms, given that these two areas will become increasingly important in helping the EU deliver on its Green Deal targets (European Commission, 2019b).

Currently, most EU policies related to the marine environment or maritime activities do not mention human health, and those that do often only mention risks; for example, the Marine Strategy Framework Directive (MSFD) (Long, 2011) highlights risks from pollution. Other policies only mention human health indirectly (e.g. through the provision of jobs). Consequently, EU policies currently do not seek to promote and enhance the multitude of potential health and wellbeing benefits provided by the marine environment to humans (Wheeler et al., 2012; White et al., 2014, 2016, 2020). Consequently, we suggest that there is far more scope to identify and build awareness of (Ståhl, 2018; Uyarra and Borja, 2016) the potential *co-benefits* of both environmental protection and health promotion (i.e. not just illness prevention) and expand the focus on reducing risks and threats, to also include far more discussion of the positive outcomes that can be achieved through well-designed policy interventions. Given that coastal tourism, for instance, is one of the top blue economy industries (European Commission, 2020a), promoting win–win environmental and health policies in this sector (e.g. the MSFD) could also have the additional benefit of greater local economic benefits (Ebi et al., 2020).

We recognise that one of the challenges in producing policies that link the marine environment and human health is that the governance of these two sectors occurs at different socio-political levels. There is a robust layer of marine environmental policy and policy intervention at EU level, whereas health is largely governed at the national level. The marine environment in Europe is interconnected, with the impact of maritime activities in the coastal waters of one Member State potentially having implications for those of another member state. The EU Maritime Spatial Planning Directive recognises this and stipulates that Member States should ensure trans-boundary cooperation (European Union, 2014). Member States are currently drawing up their maritime spatial plans, and there is a real opportunity to consider human health in the planning and implementation of these.

The COVID-19 pandemic has very clearly illustrated that health also transcends boundaries. As we emerge from a global pandemic and look to how we can grow a healthy and sustainable blue economy in line with the EU Green Deal, we need to learn lessons from our integrated approach to marine environmental monitoring and management and incorporate a pan-European consideration of human health in future maritime policy making.

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CRediT authorship contribution statement

B.R. Roberts: Software, Formal analysis, Data curation, Writing – original draft. **M.P. White:** Methodology, Writing – review & editing, Supervision, Funding acquisition. **S.M.C. Davison:** Methodology, Writing – review & editing. **O. McMeel:** Methodology, Writing – review

& editing, Funding acquisition. **C. Eatock:** Project administration, Writing – review & editing. **P. Kellett:** Writing – review & editing. **J.-B. Calewaert:** Writing – review & editing. **L.E. Fleming:** Methodology, Supervision, Writing – review & editing, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data statement

Data was collected as part of the EU Horizon 2020 funded Seas, Oceans and Public Health in Europe (SOPHIE) project and will be made publically available after a suitable moratorium period (date still under discussion with partners). Please contact the corresponding author for data access issues in the meantime. R Scripts to recreate the analysis, tables and figures for this manuscript are available at: https://doi.org/10.17632/c6mm858svc.1.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.gloenvcha.2021.102397.

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