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Concern about the human health implications of marine biodiversity loss is higher among less educated and poorer citizens: Results from a 14-country study in Europe

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Introduction: Marine biodiversity loss has direct and indirect effects on human health and wellbeing. Recent European data suggest that the public is aware of this, identifying marine biodiversity protection as its top research priority in terms of oceans and human health, rated higher than issues such as plastic, chemical, and microbial pollution.

Methods: The current study aimed to better understand key sociodemographic and personality predictors of concern about marine biodiversity loss and the desire for more research into marine biodiversity protection, in an attempt to support communication efforts targeting specific sectors in society. Data were drawn from nationally representative samples of 14 European countries (n = 14,167).

Results: Results show greater concern about marine biodiversity loss and support for more research into marine biodiversity protection by older adults, females, and individuals: (i) without (vs. with) a university degree; (ii) with lower (vs. middle) incomes; (iii) who identified as politically left-wing; (iv) who visited the coast more often; and (v) those with more open, agreeable and conscientious personalities.

Discussion: These results suggest that, although concern and research support are generally high among European citizens, policy makers and communicators need to take into consideration individual-level variation.

KEYWORDS

marine biodiversity, biodiversity protection, biodiversity loss, public perceptions, public health, oceans and human health, multi-country analysis, mediation analysis

1 Introduction

Anthropogenic factors such as overfishing, land/sea use, climate change, and pollutionare having a substantial negative impact on the biodiversity of marine environments (United Nations, 2021a; United Nations, 2021b). Globally, for example, approximately a third of marine fish stocks are currently being harvested at unsustainable levels (IPBES, 2019a). 'Biodiversity loss and extinctions' have been described as one of the nine planetary boundaries (Rockström et al., 2009; Steffen et al., 2015; EEA and FOEN, 2020), partly due to their influence on other planetary boundaries (Rockström et al., 2009).

Growing realisation about the gravity of marine biodiversity loss, has led to the issue receiving ever greater attention from policy makers. Some efforts target specific jurisdictions such as the European Union's ambitious Marine Strategy Framework Directive (MSFD; European Union, 2008) which aimed to achieve good environmental status by 2020, including ensuring that "biological diversity is maintained", across trans-national European waters. With these original targets unmet, new revised 2030 targets have been proposed for both Europe (European Commission, 2020) and further afield (Secretariat of the Convention on Biological Diversity, 2020; United Nations, 2021c). The links between biodiversity health (terrestrial and marine) and human health have been well documented (MEA, 2005; Lloret, 2010; Valderrama et al., 2010; Teh and Sumaila, 2013; Cracknell et al., 2016; Lindequist, 2016; White et al., 2017; Collins et al., 2019; Secretariat of the Convention on Biological Diversity, 2020) and they are now receiving greater policy attention (UN, 2015; IPBES, 2019b). However, knowledge about how the general public perceives these issues is relatively sparse. Given the attention paid to biodiversity decline by NGOs (e.g. World Wildlife Fund, 2018), the United Nations Decade of biodiversity (2010-2020) and widely viewed TV programmes (e.g. BBC's 'Extinction: The facts' with over 5 million viewers[1]), one might assume that the public has relatively high awareness of the negative effects of biodiversity loss, in comparison with other marine-based threats to human health (e.g. drug-resistant microbes, Leonard et al., 2018). However, biodiversity loss is still covered approximately eight times less in the media than climate change (Legagneux et al., 2018), and whilst the reasons for this are unknown, it raises question-marks about how high up on the priority list of challenges to human health and wellbeing marine biodiversity loss is perceived to be.

Understanding the general public perceptions of these issues is important because, as suggested by Gkargkavouzi et al. (2020), the management of marine resources requires understanding of "*peoples' knowledge, attitudes, values, general beliefs and perceptions toward marine biodiversity to ensure social acceptance, compliance, public support and participation, and eventually achieve more effective conservation interventions*". Drawing on data from the H2020 Seas, Oceans and Public Health In Europe survey (SOPHIE Survey[2]), Davison et al. (2021) found that marine species loss was ranked as the third greatest concern by European citizens in terms of potential impacts to human health and well-being, out of a possible 16 marine threats. Moreover, marine species protection was rated as the top research area, in terms of citizen support for research funding into better understanding health implications, out of a possible 15 research areas linked to addressing marine threats. Additionally, Davison et al. (2021) found country-level differences in the level of concern and research support into marine species loss/protection, with respondents from countries such as Bulgaria showing higher levels of concern and research support, compared to countries such as the Netherlands. However, the socio-demographic and individual difference predictors of these responses were not explored in that investigation. This information could be important in identifying which groups in society tend to have greater or lesser concern, which in turn may aid targeted communication efforts (Feinberg and Willer, 2013; Wolsko et al., 2016; Whitmarsh and Corner, 2017). The aim of the current paper was to address this gap.

Previous public perception studies have found that recreational visit frequency to marine settings had a significant positive association with concern for invasive species effects and the changing distribution of marine wildlife (Gelcich et al., 2014). Additionally, the Eurobarometer (2017) survey showed concern for "*the decline or extinction of species and habitats, and of natural ecosystems*" to be higher in younger age groups (15-24 yr) than those in older age groups (55+ yrs) and those with a higher educational attainment than those with a lower attainment. However, the impacts on human health and well-being were not explicitly considered in either study. Finally, building on the existing literature on socio-demographic predictors of environmental concern (Van Liere and Dunlap, 1980; Zelezny et al., 2000; Gifford and Nilsson, 2014; Hamilton and Safford, 2015; Hornsey et al., 2016), the Davison et al. (2021) study into public attitudes towards the health effects of marine threats found that women, those who were older, people on the political left, and again those in education, expressed greater concern for, and support for research into, the health impacts of marine plastic pollution. Engaging in coastal recreation activities, such as coastal walking and even more passive activities such as watching the view, were found to be positive predictors of concern and research support, whilst having a household member employed in a marine profession was associated with lower concern and support for research. Additionally, those with more open, conscientious and agreeable personalities expressed greater concern and research support. Perhaps unsurprisingly there was also a strong association between concern about marine plastic pollution for human health and support for more research into the issue. In combination, these findings highlight the importance of considering individual-level differences of health-related perceptions of marine issues.

From the studies reviewed, there is a lack of trans-national, representative data examining individual-level determinants of *human health-related perceptions* of marine biodiversity,

1 BBC (2020). Extinction: The Facts. Available at: https://www.bbc.co.uk/programmes/m000mn4n [Accessed July 19, 2021].

2 https://sophie2020.eu/activities/sophie-survey/

including preferences for future research. Additionally, there seems to be no literature on the role of psychological variables (e.g. personality traits) on perceptions of marine biodiversity. Therefore, the current paper aimed to understand which socio-demographic, reported marine contact, and psychological factors would predict perceptions about the *human health-related* aspects of marine biodiversity loss[3].

In summary, this paper aimed to answer the following research questions (RQs):

RQ1) To what extent do citizens across Europe vary in their concern for, and support for research into, the health impacts of marine species loss or protection;

RQ2) To what extent are individual characteristics such as socio-demographic factors (e.g. age, education and income) and political orientation, marine contact/experience factors (e.g. coastal proximity), and personality factors associated with human health-related concern over the loss of marine species (i.e. biodiversity loss) (RQ2a) and support for research funding into marine species protection (RQ2b); and

RQ3) How are concern about species loss and support for research into species protection related; specifically, like plastic pollution, does concern about the health impacts of marine species loss mediate (or account for) the relationship between any identified individual characteristics (e.g. socio-demographic factors) and research support for marine species protection in Europe?

2 Methods

2.1 The SOPHIE survey

The survey collected responses from 14,167 individuals (Mdn_{age} = 46 age range: 18-99 years, 6,898 men and 7,269 women), with approximately 1,000 respondents from each of 14 European countries sampled (Belgium, Bulgaria, Czech Republic, France, Germany, Greece, Italy, the Netherlands, Norway, Poland, Portugal, the Republic of Ireland, Spain and the United Kingdom). The 14 countries were chosen based on their bordering of one of Europe's six sea basins (i.e. Atlantic Ocean, Baltic Sea, Black Sea, Mediterranean, North Sea and Arctic), with the Czech Republic chosen as a land-locked country whose citizens may have less direct experience of marine issues. Although analysis by sea-basin was considered, we did not have data on where exactly respondents in countries with access to multiple basins (e.g. France, Germany, Norway, Spain, UK) resided, so no further analyses discusses sea-basin to avoid misclassification.

The survey was designed in collaboration with SOPHIE project partners, expert advisory board members and various marine stakeholders and translated in all relevant languages (see Roberts et al., 2021). Data were collected using established on-line panels by an international polling company between March and April 2019. Data were stratified at a country-level, representative by age, gender and region. Ethical approval was granted by the University of Exeter (ref no: Nov18/B/171).

2.2 Measures

2.2.1 Dependent variables

Although the survey contained a wide variety of items (Roberts et al., 2021), the two most relevant sets of questions examined here were: a) the level of concern expressed over the human health and wellbeing impacts of multiple marine threats and b) the level of support for more research funding into various marine research areas with the aim of better understanding the health implications.

To examine concern, respondents were asked "*How concerned do you feel about the following potential threats to human health/wellbeing*?". Respondents were then presented with 16 marine threats (Table S1, Supplementary Materials) including 'marine species loss', the marine threat of focus for our research. Support for health-related research was assessed with the question "*To what extent would you support more research funding in the following areas, to better understand health/wellbeing implications? Research into…*", with respondents presented with 15 marine research areas (Table S1 Supplementary Materials) including 'marine species/wildlife protection', the marine research area relating to this paper. Seven-point scales were used for respondents to record their response to each question (0 = not at all concerned/no support at all, 6 = extremely concerned/strong support). In the subsequent results and discussions, 'marine species loss' refers to *concern* and 'marine species protection' refers to *research support*.

2.2.2 Predictor variables

Two separate groups of models were conducted predicting: a) concern over marine species loss; and b) research preferences into marine species protection, with predictor variables selected based on previous marine-related papers (e.g. Papathanasopoulou et al., 2016; Elliott et al., 2018; Garrett et al., 2019) entered into the models in three stages (first socio-demographics and political orientation, then marine contact/experience, then personality traits). To explore RQ3, concern was additionally added as a predictor of research support in the final research support model (see also Davison et al., 2021). Details of the predictor variables, including their wording and categorisation are described in supplementary materials (Table S2). Details of sample numbers for each category of predictor variable are presented in Table 1.

2.3 Data analyses

The data collected have been added to the UK data archives and are publicly available[4]. Analyses were completed using the programme R (R Core Team, 2021). To investigate RQ1, multi-level models with 'country of residence' as a random intercept were conducted on the

3 Unlike Davison et al. (2021) which examined perceptions of European and Australia respondents together, our research focuses on perceptions of European respondents only.

4 The SOPHIE survey data are publicly available on the UK data archive: https://beta.ukdataservice.ac.uk/datacatalogue/studies/study?id=8972.

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TABLE 1 Sample sizes, correlations or means (standard deviations) of concern and research support for each variable/category included in a) marine biodiversity concern and b) marine biodiversity research support models.

	Concern models		Research Support models		Overall sample
	N	r/Mean (SD)	N	r/Mean (SD)	N
Socio-demographics and political orientation					
Age	13460	0.15	13236	0.12	14167
Gender					
Men (reference)	6565	4.97 (1.29)	6466	5.06 (1.23)	6898
Women	6895	5.20 (1.13)	6770	5.26 (1.13)	7269
Educational attainment					
'No degree' (reference)	6769	5.09 (1.23)	6643	5.17 (1.21)	7206
'Degree'	6651	5.10 (1.20)	6553	5.16 (1.16)	6882
'Missing'	40	4.69 (1.66)	40	4.72 (1.63)	79
Employment situation					
'Full time' (reference)	7573	5.03 (1.23)	7441	5.12 (1.19)	7871
'Student'	757	4.84 (1.33)	747	5.02 (1.23)	808
'Retired'	2384	5.28 (1.10)	2352	5.31 (1.09)	2493
'Other'	2577	5.17 (1.20)	2530	5.22 (1.22)	2776
'Missing'	169	4.85 (1.44)	166	4.87 (1.49)	219
Income					
'Low income'	2856	5.16 (1.20)	2806	5.21 (1.23)	3049
'Middle income' (reference)	4608	5.07 (1.23)	4537	5.16 (1.15)	4791
'High income'	4244	5.09 (1.22)	4201	5.18 (1.16)	4372
'Missing'	1752	5.04 (1.24)	1692	5.08 (1.28)	1955
Political orientation					
'Left' (reference)	2984	5.27 (1.10)	2953	5.34 (1.06)	3082
'Centre'	5303	5.09 (1.18)	5240	5.16 (1.15)	5499
'Right'	3266	4.92 (1.33)	3223	5.00 (1.27)	3394
'Missing'	1907	5.12 (1.25)	1820	5.19 (1.29)	2192
Contact/experience with the marine environment					
Coastal proximity					
'≤1 km'	1270	5.21 (1.16)	1255	5.28 (1.12)	1340
'>1-5 km'	1492	5.09 (1.23)	1467	5.22 (1.16)	1563
'>5-20 km'	1891	5.11 (1.17)	1867	5.17 (1.16)	1986
'>20 km' (reference)	8732	5.07 (1.23)	8576	5.14 (1.20)	9196
'Missing'	75	5.03 (1.47)	71	4.98 (1.46)	82
Frequency of coastal visits					
'≥ Once a week'	2178	5.28 (1.12)	2159	5.34 (1.08)	2263
'Visits the coast < once a week' (reference)	11028	5.06 (1.23)	10839	5.13 (1.20)	11575
'Missing'	254	5.01 (1.39)	238	5.12 (1.36)	329

(Continued)

TABLE 1 Continued

	Concern models		Research Support models		Overall sample
Marine recreational activities					
'Active coastal recreation' (e.g. beach/coastal walking)	11142	5.15 (1.17)	10984	5.22 (1.13)	11589
'Passive coastal recreation' (e.g. watching the view)	11453	5.14 (1.17)	11289	5.22 (1.14)	11920
'Recreational water sports' (e.g. surfing)	3818	5.08 (1.22)	3765	5.17 (1.18)	3968
'Swimming'	6744	5.12 (1.21)	6656	5.21 (1.15)	6985
'Eating seafood'	6218	5.24 (1.10)	6154	5.31 (1.09)	6389
'Other'	147	5.05 (1.42)	145	5.09 (1.45)	156
'Missing'	38	4.06 (2.01)	35	3.99 (1.96)	71
'None' (reference)	655	4.80 (1.45)	614	4.88 (1.46)	733
Marine sector occupation					
'Marine occupation in household'	1329	4.98 (1.33)	1305	5.07 (1.22)	1429
'No marine occupation in household' (reference)	11645	5.11 (1.19)	11461	5.19 (1.17)	12171
'Missing'	486	4.97 (1.39)	470	4.91 (1.47)	567
Personality traits					
Openness	13460	0.08	13236	0.09	14030
Conscientiousness	13460	0.04	13236	0.05	14006
Extraversion	13460	0.02	13236	0.02	14035
Agreeableness	13460	0.04	13236	0.06	14038
Neuroticism	13460	0.00	13236	0.00	14048
Concern	–	–	13236	0.59	13864

final models to explore the country level variation in a) concern over the health impacts of marine species loss, and b) research support into the health implications of marine species protection.

To explore RQ2a and RQ2b which aimed to investigate if individual-level characteristics predicted a) concern for marine species loss and b) research support for marine species protection, hierarchical multi-level regression models were built with the function 'lmer' from the package 'lme4' (Bates et al., 2015). To answer RQ3 regarding whether concern mediated the relationship between individual characteristics and research support, a second model was created for predicting research support which added concern to the previous model. Any decrease or reduction of significance of coefficients would be indicative of mediation which was subsequently tested by the R function 'mediation' (Tingley et al., 2014). This separated each characteristic's effect on research support into direct, indirect and total effects, and indicated if they were significant.

Models had 'country of residence' as a random intercept and following previous environmental concern literature (Nawrotzki, 2012; Aspelund et al., 2013; Poortinga et al., 2019), political orientation as a random slope, to account for national-level respondent clustering and cross-country variation in the effect of political orientation on concern and research support. Survey weights were used in all models to maintain national representativeness with regards to the sampling strata within each country (i.e. sex, age, and region of residence) using the R function 'rescale_weights' from package 'parameters' (Lüdecke et al., 2020). Correlations and means for each of the variables contained in the models can be seen in supplementary materials Table S1. The models for research support with and without concern were compared using the ANOVA function (R Core Team, 2021).

Due to non-normally distributed outcome variables, models were also run with the Gamma family and identity link. The akaike information criterion (AIC) of models were compared, and the Gaussian models were found to have the lowest AIC. Model estimates were largely consistent across models, therefore Gaussian models were used, consistent with findings that Gaussian models can be robust to non-normal data (Schielzeth et al., 2020; Knief and Forstmeier, 2021).

3 Results

3.1 Country variation in marine biodiversity perceptions

In response to RQ1, the country-level random intercepts of models predicting concern for the health impacts of marine species loss and support for research into the health implications of marine species protection are shown in Figure 1. Figure 1A, B show how

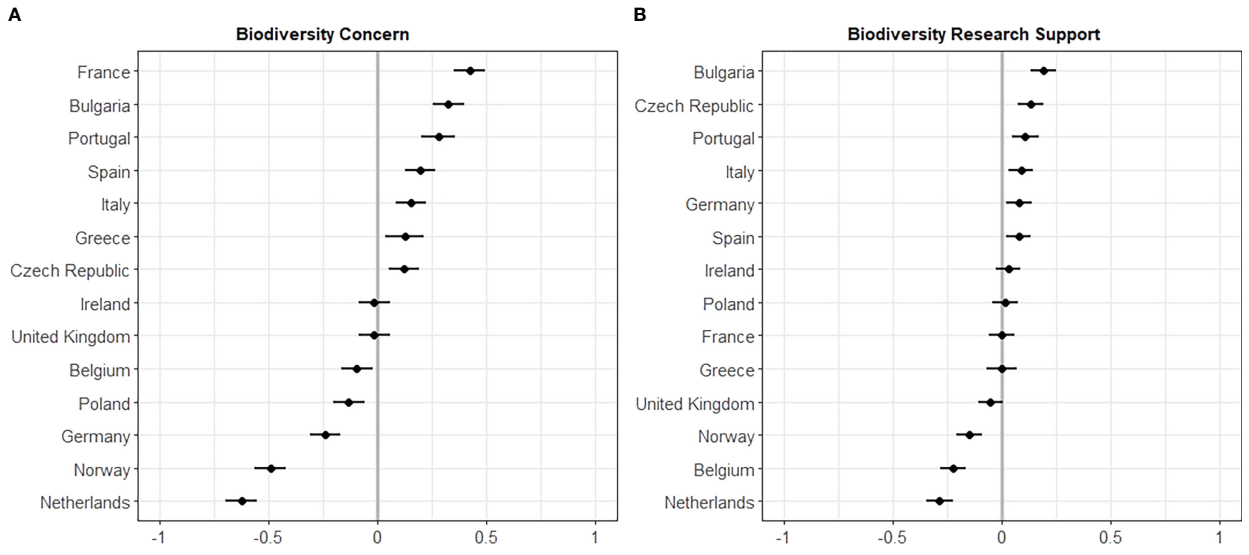

FIGURE 1
Country-level intercepts (ranked from highest to lowest in each case) from final models predicting health-related concern for **(A)** marine species loss (Biodiversity Concern Model 1), and **(B)** support for health-related research funding into marine species protection (Biodiversity Research Model 2). Scores for each country represent divergence from the grand mean (with 95% confidence intervals) across all countries, and not absolute scores (so France was significantly above average for concern, whereas Netherlands was significantly below average).

each country differs from the respective overall model intercept. Details of how country level intercepts were retrieved are contained in the data analyses section above. Figure 1 suggests that there was more country-level variation in concern over the loss of marine species than in support for research into marine species protection. This suggests that countries were more aligned on support for research, than on concern.

Figure 1 also shows that some countries ranked low compared to others on both concern and research support, such as the Netherlands, Norway and Belgium. In contrast, other countries ranked relatively high on both, such as Bulgaria and Portugal. Of note, non-overlap of 95% confidence intervals is conceptually equivalent to the scores of the countries being significantly different. For some countries such as France, there appears to be variation depending on the variable in question, with concern ranking relatively high in comparison with other countries, yet research support remaining average in comparison with other countries.

3.2 Predicting European concern for the public health/wellbeing impacts of marine species loss

Table 2 (Column 2) shows the multi-level model predicting concern for the human health impacts of marine species loss ('biodiversity concern') across 14 European nations (RQ2a). In terms of socio-demographics, results found that older respondents (β = 0.17, 95% CIs: 0.14, 0.20), and females (β = 0.17, 95% CIs: 0.13, 0.20), were significantly more concerned about the public health impacts of marine species loss than those younger adults and males. By contrast, those with a degree were less likely to be concerned than those without a degree (β = -0.05, 95% CIs: -0.09, 0.00), and those in the lowest income category (β = 0.10, 95% CIs: 0.04, 0.15) were significantly more concerned than those in the middle-income category (and also more concerned than those in the highest category although this wasn't directly compared). Political orientation was also shown to be significantly associated with concern, with those aligned with the centre (β = -0.14, 95% CIs: -0.22, -0.05) and right (β = -0.26, 95% CIs: -0.39, -0.13) expressing lower concern than those who aligned with the left.

In terms of marine contact/experience variables, those who visited the coast once a week or more often (β = 0.08, 95% CIs: 0.01, 0.15) were significantly more concerned than those who visited less often. Those who engaged in active beach activities (β = 0.18, 95% CIs: 0.12, 0.24), passive beach activities (β = 0.13, 95% CIs: 0.07, 0.20), water sports (β = 0.06, 95% CIs: 0.01, 0.11), eating seafood (β = 0.13, 95% CIs: 0.08, 0.17) or other activities (β = 0.33, 95% CIs: 0.14, 0.53) whilst visiting the coast were significantly more concerned than those who engaged in no coastal recreation activities. Those who engaged in swimming (β = 0.00, 95% CIs: -0.04, 0.05), however, did not differ in their concern from those who engaged in no coastal recreation. Neither home proximity to the coast nor having a family member engaged in a maritime occupation were related to concern.

Finally, in terms of personality, those higher in openness (β = 0.09, 95% CIs: 0.06, 0.11), conscientiousness (β = 0.05, 95% CIs: 0.02, 0.07) and agreeableness (β = 0.03, 95% CIs: 0.01, 0.06) were found to be significantly more concerned than those lower in these personality traits. No significant effects were found for extraversion (β = 0.01, 95% CIs: -0.01, 0.03) or neuroticism (β = 0.01, 95% CIs: -0.01, 0.03). Biodiversity concern Model 1 explained 13% of the variance in concern for the public health impacts of marine species loss.

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TABLE 2 Multi-level regression analyses predicting concern for the human health impacts of marine species loss and support for research funding into better understanding the health impacts of marine species protection using 'country of residence' as a random intercept and 'political orientation' as a random slope.

	Biodiversity Concern Model 1	Biodiversity Research Model 1	Biodiversity Research Model 2 *(+ Concern)*
	B [95% CI]	*B [95% CI]*	*B [95% CI]*
(Intercept)	4.15 ***	4.34 ***	2.11 ***
	[3.94, 4.35]	[4.15, 4.54]	[1.95, 2.28]
Socio-demographics			
Age (18 to 99)	0.17 ***	0.13 ***	0.04 ***
	[0.14, 0.20]	[0.11, 0.16]	[0.02, 0.07]
Gender (ref: Men)			
Women	0.17 ***	0.14 ***	0.05 **
	[0.13, 0.21]	[0.10, 0.18]	[0.02, 0.09]
Education (ref: No Degree)			
Degree	-0.05 *	-0.06 **	-0.04 *
	[-0.09, -0.00]	[-0.10, -0.02]	[-0.07, -0.00]
Missing	-0.20	-0.21	-0.12
	[-0.56, 0.16]	[-0.56, 0.14]	[-0.41, 0.18]
Employment (ref: Full time Employment)			
Student	0.03	0.10 *	0.09 *
	[-0.06, 0.12]	[0.00, 0.19]	[0.01, 0.17]
Retired	-0.01	0.00	0.01
	[-0.08, 0.05]	[-0.07, 0.06]	[-0.05, 0.06]
Other	0.06 *	0.05	0.01
	[0.00, 0.11]	[-0.01, 0.10]	[-0.03, 0.06]
Missing	-0.17	-0.19 *	-0.08
	[-0.35, 0.01]	[-0.37, -0.01]	[-0.23, 0.07]
Income (ref: Middle)			
Low	0.10 ***	0.06 *	0.00
	[0.04, 0.15]	[0.00, 0.11]	[-0.04, 0.05]
High	-0.02	-0.04	-0.04
	[-0.07, 0.03]	[-0.09, 0.01]	[-0.08, 0.01]
Missing	0.03	-0.04	-0.06 *
	[-0.03, 0.10]	[-0.10, 0.03]	[-0.11, -0.00]
Political orientation (ref: Left)			
Centre	-0.14 **	-0.15 ***	-0.07 **
	[-0.22, -0.05]	[-0.22, -0.08]	[-0.12, -0.02]
Right	-0.26 **	-0.26 ***	-0.11 **
	[-0.39, -0.13]	[-0.37, -0.15]	[-0.18, -0.05]
Missing	-0.11	-0.11	-0.05

(Continued)

TABLE 2 Continued

	Biodiversity Concern Model 1	Biodiversity Research Model 1	Biodiversity Research Model 2 *(+ Concern)*
	[-0.22, -0.01]	[-0.22, -0.00]	[-0.12, 0.03]
Marine contact/experience			
Coastal proximity (ref: +20 km)			
≤1km	0.02	0.05	0.04
	[-0.07, 0.11]	[-0.04, 0.14]	[-0.04, 0.11]
>1-5km	-0.02	0.03	0.04
	[-0.09, 0.05]	[-0.04, 0.10]	[-0.02, 0.10]
>5-20km	0.02	0.01	-0.00
	[-0.05, 0.08]	[-0.05, 0.08]	[-0.05, 0.05]
Missing	-0.10	-0.19	-0.16
	[-0.36, 0.16]	[-0.45, 0.07]	[-0.38, 0.06]
Visit frequency (ref: Less often than once a week)			
Once a week or more	0.08 *	0.08 *	0.04
	[0.01, 0.15]	[0.01, 0.15]	[-0.02, 0.09]
Missing	0.01	0.02	0.02
	[-0.14, 0.15]	[-0.12, 0.17]	[-0.10, 0.14]
Recreation activities (ref: no activities)			
Active beach	0.18 ***	0.17 ***	0.08 **
	[0.12, 0.24]	[0.11, 0.23]	[0.03, 0.13]
Passive beach	0.13 ***	0.14 ***	0.07 **
	[0.07, 0.20]	[0.07, 0.20]	[0.02, 0.13]
Watersports	0.06 *	0.04	0.01
	[0.01, 0.11]	[-0.00, 0.09]	[-0.03, 0.05]
Swimming	0.00	0.01	0.01
	[-0.04, 0.05]	[-0.03, 0.06]	[-0.02, 0.05]
Eating seafood	0.13 ***	0.12 ***	0.06 **
	[0.08, 0.17]	[0.08, 0.16]	[0.02, 0.09]
Other	0.33 ***	0.32 **	0.14
	[0.14, 0.53]	[0.13, 0.51]	[-0.02, 0.31]
Missing	-0.47 *	-0.60 **	-0.35 *
	[-0.84, -0.10]	[-0.98, -0.22]	[-0.67, -0.03]
Marine sector occupation (ref: No marine occupation in household)			
Household member has a marine occupation	-0.05	-0.05	-0.03
	[-0.12, 0.02]	[-0.12, 0.01]	[-0.09, 0.03]
Missing	-0.09	-0.22 ***	-0.16 ***
	[-0.19, 0.02]	[-0.32, -0.11]	[-0.25, -0.07]

(Continued)

TABLE 2 Continued

	Biodiversity Concern Model 1	Biodiversity Research Model 1	Biodiversity Research Model 2 *(+ Concern)*
Psychological factors			
Personality traits			
Openness (1 to 5)	0.09 ***	0.08 ***	0.03 **
	[0.06, 0.11]	[0.05, 0.10]	[0.01, 0.05]
Conscientiousness (1 to 5)	0.05 ***	0.03 **	0.01
	[0.02, 0.07]	[0.01, 0.06]	[-0.01, 0.03]
Extraversion (1 to 5)	0.01	0.00	-0.01
	[-0.01, 0.03]	[-0.02, 0.02]	[-0.03, 0.01]
Agreeableness (1 to 5)	0.03 *	0.05 ***	0.03 **
	[0.01, 0.06]	[0.02, 0.08]	[0.01, 0.06]
Neuroticism (1 to 5)	0.01	0.00	-0.00
	[-0.01, 0.03]	[-0.02, 0.02]	[-0.02, 0.01]
Concern about marine species loss			0.53 ***
			[0.52, 0.55]
N (respondents)	13460	13236	13236
N (country)	14	14	14
AIC	42350.90	41185.32	36615.44
R2 (fixed)	0.06	0.06	0.35
R2 (total)	0.13	0.11	0.36

*** p < 0.001, **p < 0.01, *p < 0.05. CI = confidence interval. Ns < 14,167 due to missing data.

3.3 Predicting European support for research funding in marine species protection

3.3.1 Multi-level linear regression analysis

Table 2 (Columns 3 & 4) shows models predicting support for research funding into the health implications of marine species protection ('biodiversity research') across the 14 European nations surveyed (RQ2b). Similarly to the model for concern, biodiversity research Model 1 (which included the same predictors as for concern) also found that those who were older (β = 0.13, 95% CIs: 0.11, 0.16), female (β = 0.14, 95% CIs: 0.10, 0.18), or in the lowest income category (β = 0.06, 95% CIs: 0.00, 0.11) were significantly more concerned about the public health impacts of marine species loss than those who were younger, male, or in the middle-income category. Again, like concern, those with a degree showed less support for research in this area than those without (β = -0.06, 95% CIs: -0.10, -0.02), though this time, those in education were at least significantly more supportive of biodiversity research than those in full time employment (β = 0.10, 95% CIs: 0.00, 0.19). As with concern, those with centre-aligned (β = -0.15, 95% CIs: -0.22, -0.08) and right-aligned (β = -0.26, 95% CIs: -0.37, -0.15) political beliefs reported lower levels of support than those who aligned with the left.

In terms of marine contact/experience variables, those who visited the coast once a week or more indicated more research support than those who visited less often (β = 0.08, 95% CIs: 0.01, 0.15). Additionally, engaging in active beach activities (β = 0.17, 95% CIs: 0.11, 0.23), passive beach activities (β = 0.14, 95% CIs: 0.07, 0.20), eating seafood (β = 0.12, 95% CIs: 0.08, 0.16) or other forms of recreation (β = 0.32, 95% CIs: 0.13, 0.51) when visiting the coast were all positively related to research support. On the other hand, those who engaged in water sports or swimming did not differ in their research support from those who did not engage in any coastal recreation. Neither coastal proximity nor marine sector occupation were significantly associated with research support. Again, in terms of personality, openness (β = 0.08, 95% CIs: 0.05, 0.10), conscientiousness (β = 0.03, 95% CIs: 0.01, 0.06) and agreeableness (β = 0.05, 95% CIs: 0.02, 0.08) were shown to be significant positive predictors of research support. The model explained 11% of the variation in research support.

Adding concern for the public health impacts of marine species loss as a predictor (biodiversity research Model 2) resulted in a significant improvement on model 2 (X^2 = 4844.92; p < 0.001). Concern was a significant positive predictor of research support (β = 0.53, 95% CIs: 0.52, 0.55). The final model explained 36% of the total variance in research support, an increase of 25% from Model 1.

3.3.2 Mediation analysis

To answer RQ3, mediation analysis was conducted for each variable whose effect may have been mediated by concern in

TABLE 3 Mediation analysis predicting support for research into marine species protection *via* concern for marine species loss.

Predictor variables	Estimate *(95% CI)*
Age (18 to 99)	
Direct effect	0.04 (0.02, 0.07)***
Indirect effect	0.09 (0.08, 0.11)***
Total effect	0.13 (0.11, 0.16)***
Gender: women (vs. men)	
Direct effect	0.06 (0.02, 0.09)**
Indirect effect	0.09 (0.07, 0.11)***
Total effect	0.14 (0.11, 0.18)***
Education: degree (vs. no degree)	
Direct effect	-0.04 (-0.07, 0.00)*
Indirect effect	-0.02 (-0.04, 0.00)
Total effect	-0.06 (-0.10, -0.02)**
Income: low (vs. middle)	
Direct effect	0.003 (-0.04, 0.05)
Indirect effect	0.05 (0.03, 0.08)***
Total effect	0.06 (0.004, 0.11)*
Employment: student (vs. full time)	
Direct effect	0.09 (0.01, 0.17)*
Indirect effect	0.01 (-0.04, 0.06)
Total effect	0.10 (0.01, 0.19)*
Political orientation (centre vs. left)	
Direct effect	-0.07 (-0.11, -0.02)**
Indirect effect	-0.07 (-0.12, -0.03)**
Total effect	-0.14 (-0.21, -0.07)***
Political orientation (right vs. left)	
Direct effect	-0.11 (-0.18, -0.05)***
Indirect effect	-0.14 (-0.21, -0.06)***
Total effect	-0.25 (-0.35, -0.16)***
Visit frequency: once a week or more (vs. less often)	
Direct effect	0.03 (-0.02, 0.09)
Indirect effect	0.04 (0.01, 0.08)*
Total effect	0.08 (0.01, 0.15)*
Recreation activities: active (vs. none)	
Direct effect	0.08 (0.03, 0.13)**
Indirect effect	0.10 (0.06, 0.13)***
Total effect	0.17 (0.11, 0.23)***
Recreation activities: passive (vs. none)	
Direct effect	0.07 (0.02, 0.12)*
Indirect effect	0.06 (0.03, 0.10)***
Total effect	0.13 (0.07, 0.19)***
Recreation activities: eating seafood (vs. none)	
Direct effect	0.06 (0.02, 0.09)**
Indirect effect	0.06 (0.04, 0.09)***
Total effect	0.12 (0.08, 0.17)***
Personality: openness (1 to 5)	
Direct effect	0.03 (0.01, 0.05)***
Indirect effect	0.04 (0.03, 0.06)***
Total effect	0.08 (0.05, 0.10)***
Personality: conscientiousness (1 to 5)	
Direct effect	0.01 (-0.01, 0.03)
Indirect effect	0.03 (0.01, 0.04)***
Total effect	0.03 (0.01, 0.06)***
Personality: agreeableness (1 to 5)	
Direct effect	0.03 (0.01, 0.05)**
Indirect effect	0.02 (0.002, 0.03)*
Total effect	0.05 (0.02, 0.07)***

*** p < 0.001, **p < 0.01, *p < 0.05. CI = confidence interval. Results based on 1000 simulations per model.

biodiversity research Model 2. Table 3 confirms that the effects of age, gender, centre-aligned political orientation, right-aligned political orientation, active coastal recreation, passive coastal recreation, seafood consumption, openness and agreeableness on research support were partially mediated by concern, whilst the effects of having a lower income, visit frequency and conscientiousness on research support for marine species protection were fully mediated *via* concern. Interestingly the mediation analysis showed that having no degree and being currently in education actually showed no significant indirect effect. That is, greater desire for research was not being driven by concern among these individuals.

4 Discussion

Marine species loss is an issue of major environmental importance and has been described as a planetary boundary (Rockström et al., 2009; Steffen et al., 2015; Nash et al., 2017; EEA and FOEN, 2020). If we are to mobilise public action on the issue, determining which individuals are more/less concerned by biodiversity loss and supportive of research into its interactions with human health has never been more important (WHO, 2015; Marselle et al., 2021; WHO, 2021). It is perhaps reassuring that Davison et al. (2021) found that the potential human health impacts of marine species loss was one of the issues the European public were most concerned about (after marine plastics), and that the

implications for human health of marine species protection was ranked as the most important area for further research.

In this context, our research built upon these findings by investigating which individuals express higher/lower levels of concern for marine species loss and support for research into marine species protection. These results can aid policy makers to better understand the likely public reception of new policies, as well as inform communication experts and NGOs focused on protecting the marine environment to create more tailored environmental communications (Whitmarsh and Corner, 2017).

4.1 Individual-level predictors of health-related marine biodiversity perceptions

Research question RQ1 sought to examine if there was country-level variation in marine biodiversity perceptions. Plotting of country-level random intercepts revealed that some countries (e.g. Bulgaria) ranked high in terms of concern about, and support for research into, marine species loss/protection, whilst others ranked relatively low in comparison to other countries (e.g. the Netherlands). These results emphasise that, as with climate change perceptions research (Poortinga et al., 2019), health-related perceptions of marine biodiversity do vary as a function of country of residence when taking into consideration other individual-level characteristics (i.e. socio-demographic and political factors, marine contact/experience factors and personality traits). These differences may be of interest to marine policy makers across Europe and beyond.

The second RQ concerned which individual-level characteristics (e.g. socio-demographic, marine contact/experience and personality factors) predicted concern for the health impacts of marine species loss (RQ2a) and support for research into the health implications of marine species protection (RQ2b). We found that education level and income were associated with both concern and research support.

Somewhat surprisingly, having a degree (although we do not know in which subject) was associated with both lower concern over the loss of marine species and lower support for research funding into marine species protection. This finding is contrary to the Eurobarometer (2017) results which found those with higher educational attainment were more concerned about the decline or extinction of species and habitat in general (i.e. not marine specific) and Gifford and Nilsson (2014) who also showed higher educational attainment correlated positively with environmental concern. Future surveys should compare public concern about marine biodiversity loss with concern about biodiversity more generally, with and without a focus on human health, in the same population, to clarify these differences. Such work may be of particular interest to the ocean literacy movement because they support the idea that high levels of formal education are not required to appreciate and be concerned about the issues.

Another key socio-demographic factor which was found to be important was income, with a 'lower' income (in contrast to a 'middle income') associated with both more concern about loss of marine species and support for more research funding into marine species protection. These results again contrast with (albeit dated) findings on environmental concern generally (Franzen and Meyer, 2010).

We also investigated the impact of variables centred on contact/experience with the marine environment. It was theorised that individuals who physically engaged with the coast/marine environment more often (e.g. through visiting more often, living by the coast, etc.) would be more exposed to the marine issues in question and therefore have different attitudes towards the marine issues than those who are less exposed (Gelcich et al., 2014; Strain et al., 2019; Román et al., 2022). Consistent with this possibility, coastal visit frequency was positively associated with both concern over the health impacts of loss of marine species and support for research funding investigating the health and wellbeing impacts of marine species protection. This supports the findings of Gelcich et al. (2014) who also found visit frequency to be associated with an increased concern for the distribution of marine species. However, no association was found between the coastal proximity of the respondent home and either of the outcome variables.

Similarly, previous research has shown that those who engaged in leisure activities near harbours (Strain et al., 2019) or surfing-related activities (Román et al., 2022) were more concerned about the harbour/beach environment respectively, than those who did not. The current results also support these findings suggesting that those who engaged in activities such as coastal walking (i.e. active coastal recreation), sunbathing (i.e. passive coastal recreation), and surfing (i.e. water sports), for instance, all had higher concern about marine biodiversity loss compared to those who did not engage in any coastal recreation, although no associations were found between engagement in water sports and support for research funding into marine species protection. These findings could be examined further through an independent measures design in which the health-related concerns and support of a control group is compared with a group which have had their coastal leisure activity increased. No association was found between engagement in coastal swimming and health-related concern over marine species loss and research support for marine species protection.

Openness, conscientiousness, and agreeableness were found to be significant positive predictors of health-related concern for marine species loss and support for research funding into marine species protection, with those more open, conscientious and agreeable personalities exhibiting more concern and support. These findings fit with the suggestion of openness and agreeableness in particular being linked to values which focus on nature appreciation and care for others (Olver and Mooradian, 2003). Future survey work should examine these links between personality traits, values and health-related concern and research support.

These results suggest that engaging individuals who are low in openness, conscientiousness and agreeableness may be particularly important in communications surrounding marine biodiversity. Soutter et al. (2020) meta-analysis also found openness to be related to environmental concern; and they suggested that those low in openness may be more reluctant to try new environmental

practices, stating that "*it may not be helpful to frame environmentally friendly practices as novel but rather demonstrate the extent to which they are already established; those on the lookout for novel practices are already more likely to behave pro-environmentally*" (Soutter et al., 2020). Therefore, framing marine biodiversity strategies as established may be more highly accepted by those low in openness. This is only a hypothesis and would be for future research to test experimentally by comparing the perceptions before and after reading a novelty-framed communication.

The strongest predictor of research support for the protection of marine species was, however, concern for loss of marine species. This was perhaps to be expected, given Davison et al. (2021) found concern for health-related impacts of marine plastic pollution to be the largest predictor of support for health-related research into the issue.

In response to RQ3, mediation analysis revealed two quite different patterns emerged for two of our, perhaps most interesting, findings. First, like coastal visits, the relationship between income and support for research into marine biodiversity loss was fully mediated by concern. This suggests the reason why those on lower incomes wanted more research was because they were more concerned. However, by contrast, the relationship between educational attainment (having a degree or not) and research preferences was not mediated by concern, reflecting the lack of association between education and concern in the basic regression model. Clearly, further research is needed to explore these income and education related findings in more detail.

4.2 Future research and limitations

Substantial variation in the concern for marine species loss and support for research into marine species protection were left unexplained. Therefore, further research may wish to examine other predictors of health-related marine species perceptions. This paper's purpose is to outline possible associations between individual characteristics and concern for and support for research into the health impacts of marine biodiversity loss and protection found within our dataset. Although we have discussed some potential hypotheses for these associations, we understand that there are many other potential hypotheses and that it will be for future work to draw these inferences from more causality-driven, focused methods.

For instance, earlier work in the field of marine (Ressurreição et al., 2012) and coastal (Martín-López et al., 2007) biodiversity loss/protection explored attitudes towards different taxa (e.g. marine mammals, birds, invertebrates, algae etc.), rather than the more generic 'marine species' investigated here. These studies found that not only did protection motivations vary quite substantially across different taxa (with mammals and birds generally valued higher than invertebrates and plants), reactions to these different taxa varied both across cultural groups (Martín-López et al., 2007) and different country case study sites (Ressurreição et al., 2012). For instance, motives for biodiversity protection ranged from utilitarian potential (local residents), scientific rarity (environmentalists) and affective considerations (visitors; Martín-López et al., 2007), and certain communities (e.g. resident of the Isles of Scilly) rated some species (e.g. algae) higher than others (e.g. resident of the Azores or Gdansk). Further, these studies also adopted contingent valuation approaches (CVA) in order to determine participant's Willingness to Pay (WTP) for (hypothetical) protection measures which enabled them to both explore different underlying values for protection (including direct and indirect use values as well as existence and bequest values) and provide monetary estimates of value which might be relevant to policy and conservation prioritisation. Despite these strengths, these and similar studies also acknowledge that even species richness is only one aspect of biodiversity, and that even less is known about public attitudes towards issues such as genetic, ecosystem and functional diversity. In sum, further work using large representative multi-country surveys like our own might nevertheless explore marine biodiversity issues in more depth by examining the reactions of different social groups and country residents to different aspects of biodiversity in more detail and/or by using alternative valuation methods in future.

A further limitation with the current work is its focus on the European public. Given that it is low- and middle- income countries that are likely to be worst affected by biodiversity loss (Pauly et al., 2005; Roxburgh et al., 2020; WHO, 2021), it will be vital to take into consideration the thoughts of those in these countries going forward, as well as those of specific societal groups (e.g. small-scale fishers and fishing communities; Madarcos et al., 2021). Future research could gather further public perceptions data using representative and specifically targeted groups from nations across Asia, South America and Africa to see if the associated livelihoods that fishing provides influences perceptions of marine biodiversity loss.

The current study also lacked a baseline of control measures which established concern for, and support of research, into marine biodiversity more generally, to compare to the concern and support for research related to the human health implications of marine biodiversity in particular. Therefore, it is unclear how much concern and research support were driven by perceptions of the wider ecological issue, versus human health specifically.

It might also be beneficial to adopt qualitative methods to gather more in-depth data on perceptions of the health impacts of marine biodiversity (e.g. using a Mental Models Approach; Morgan et al., 2002; Boase et al., 2019). For example, it would be useful for future research to understand if marine biodiversity is perceived differently between Bulgarian respondents (who supported research into marine species protection the most) and respondents from the Netherlands (who supported research into marine species protection the least). Sea-basin differences could be investigated by collecting specific addresses or greater details about the nearest coastline for each respondent, and/or conducting more in-depth interviews into people's lived experiences of different coastal settings.

Additionally, unlike other multi-country surveys (e.g. ESS, Eurobarometer), although samples were representative on age, gender and region within country, the sample was not fully

representative, therefore caution should be taken when inferring findings about specific countries from the current sample. The present survey was also designed to get an initial broad overview of public perceptions relating to the potential health implications of the marine environment and the predictors of such perceptions. We are therefore unable to infer causality from our findings, a limitation associated with cross-sectional survey methodology in general.

Finally, we also recognise that the data were collected before the Covid-19 pandemic and that concern about environmental issues, including (marine) biodiversity loss may have decreased since this data were collected, given the 'limited pool of worry' hypothesis which suggests people may reduce environmental concerns in the face other more pressing issues. Despite this possibility, a repeat cross-sectional study with samples in Canada, Norway and Scotland in Oct/Nov 2019 (Pre-pandemic) and May 2020 (during the pandemic) found relatively little change in people's trade-off preferences in the relative importance of a range of marine related issues including health of commercial fish stocks, density of marine litter, and size of marine protected areas over the two time points (Hynes et al., 2021). More broadly, a longitudinal study in the UK, also suggests that the Covid-19 pandemic did not reduce concern about climate change and people believed that climate change was ultimately a greater threat than the pandemic (Evensen et al., 2021). In short, there is good reason to believe that current pre-pandemic data is still relevant today.

5 Conclusions

This paper explored the effect of individual-level characteristics in predicting concern over the human health impacts of marine species loss and support for research into the health implications of marine species protection. Some of our findings were consistent with other environmental issues. For instance, females and those on the political left showed more concern and greater support for research into how to protect marine biodiversity. Perhaps more interestingly, people with lower incomes and those without a degree also showed more concern than those on higher incomes and those with a degree suggesting that ocean connectedness and possibly ocean literacy are not the preserve of richer more educated individuals. Moreover, the consistent findings in relation to personality factors and systematic differences across country alert communicators aiming to increase awareness, concern and support for marine protection research/measures to the need to design tailored messages to different audiences.

Data availability statement

The deidentified participant data from the SOPHIE survey and corresponding codebook are available after registration via the UK Data Service (https://doi.org/10.5255/UKDA-SN-8972-1; https://beta.ukdataservice.ac.uk/datacatalogue/studies/study?id=8972).

Ethics statement

The studies involving human participants were reviewed and approved by University of Exeter (ref no: Nov18/B/171). Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

Author contributions

MW, SD, LF, OM, PK, SP, and TT developed the survey and the specific items used here. The current paper formed part of SD's PhD, supervised by MW, SP and TT. SD, MW and BR developed the analysis plan and conducted all analyses, and AB brought particular topic expertise. SD wrote the first complete draft of the manuscript and all authors made substantive contributions to the extensive revisions. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmars.2023.949263/full#supplementary-material

References

Aspelund, A., Lindeman, M., and Verkasalo, M. (2013). Political conservatism and left-right orientation in 28 Eastern and Western European countries. *Political Psychol.* 34 (3), 409–417. doi: 10.1111/pops.12000

Bates, D., Mächler, M., Bolker, B., and Walker, S.. (2015). Fitting linear mixed-effects models using lme4. *J. Stat. Software* 67 (1), 1–48. doi: 10.18637/jss.v067.i01

Boase, N. J., White, M. P., Gaze, W. H., and Redshaw, C. H.. (2019). Why don't the British eat locally harvested shellfish? the role of misconceptions and knowledge gaps. *Appetite* 143, 104352. doi: 10.1016/j.appet.2019.104352

Collins, J. E., Harden-Davies, H., Jaspars, M., Thiele, T., Vanagt, T., and Huys, I.. (2019). Inclusive innovation: Enhancing global participation in and benefit sharing linked to the utilization of marine genetic resources from areas beyond national jurisdiction. *Mar. Policy* 109, 103696. doi: 10.1016/j.marpol.2019.103696

Cracknell, D., White, M. P., Pahl, S., Nichols, W. J., and Depledge, M. H.. (2016). Marine biota and psychological well-being: A preliminary examination of dose–response effects in an aquarium setting. *Environ. Behav.* 48 (10), 1242–1269. doi: 10.1177/0013916515597512

Davison, S. M., White, M. P., Pahl, S., Taylor, T., Fielding, K., Roberts, B. R, et al. (2021). Public concern about, and desire for research into, the human health effects of marine plastic pollution: Results from a 15-country survey across Europe and Australia. *Global Environ. Change* 69, 102309. doi: 10.1016/j.gloenvcha.2021.102309

EEA and FOEN (2020). *Is Europe living within the limits of our planet? an assessment of europe's environmental footprints in relation to planetary boundaries*. Publications Office, Copenhagen Denmark. doi: 10.2800/537187

Elliott, L. R., White, M. P., Grellier, J., Rees, S. E., Waters, R. D., and Fleming, L. E. (2018). Recreational visits to marine and coastal environments in England: Where, what, who, why, and when? *Mar. Policy* 97, 305–314. doi: 10.1016/j.marpol.2018.03.013

European Commission (2020). *Communication from the commission of the European parliament, the council, the European economic and social committee and the committee of the regions, EU biodiversity strategy for 2030, bringing nature back into our lives* (Brussels), 27.

European Union (2008). DIRECTIVE 2008/56/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine strategy framework directive). *Off. J. Eur. Union*.

Evensen, D., Whitmarsh, L., Bartie, P., Devine-Wright, P., Dickie, J., Varley, A., et al. (2021). Effect of "finite pool of worry" and COVID-19 on UK climate change perceptions. *Proc. Natl. Acad. Sci.* 118 (3), e2018936118. doi: 10.1073/pnas.2018936118

Feinberg, M., and Willer, R. (2013). The moral roots of environmental attitudes. *psychol. Sci.* 24 (1), 56–62. doi: 10.1177/0956797612449177

Franzen, A., and Meyer, R. (2010). Environmental attitudes in cross-national perspective: A multilevel analysis of the ISSP 1993 and 2000. *Eur. Sociol Rev.* 26 (2), 219–234. doi: 10.1093/esr/jcp018

Garrett, J. K., Clitherow, T. J., White, M. P., Wheeler, B. W., and Fleming, L. E.. (2019). Coastal proximity and mental health among urban adults in England: The moderating effect of household income. *Health Place* 59, 102200. doi: 10.1016/j.healthplace.2019.102200

Gelcich, S., Buckley, P., Pinnegar, J. K., Chilvers, J., Lorenzoni, I., Terry, G., et al. (2014). Public awareness, concerns, and priorities about anthropogenic impacts on marine environments. *Proc. Natl. Acad. Sci.* 111 (42), 15042–15047. doi: 10.1073/pnas.1417344111

Gifford, R., and Nilsson, A. (2014). Personal and social factors that influence pro-environmental concern and behaviour: A review. *Int. J. Psychol.* 49 (3), 141–157. doi: 10.1002/ijop.12034

Gkargkavouzi, A., Paraskevopoulos, S., and Matsiori, S. (2020). Public perceptions of the marine environment and behavioral intentions to preserve it: The case of three coastal cities in Greece. *Mar. Policy* 111, 103727. doi: 10.1016/j.marpol.2019.103727

Hamilton, L. C., and Safford, T. G. (2015). Environmental views from the coast: Public concern about local to global marine issues. *Soc. Natural Resour.* 28 (1), 57–74. doi: 10.1080/08941920.2014.933926

Hornsey, M. J., Harris, E. A., Bain, P. G., and Fielding, K. S.. (2016). Meta-analyses of the determinants and outcomes of belief in climate change. *Nat. Climate Change* 6 (6), 622–626. doi: 10.1038/nclimate2943

Hynes, S., Armstrong, C. W., Xuan, B. B., Ankamah-Yeboah, I., Simpson, K., Tinch, R., et al. (2021). Have environmental preferences and willingness to pay remained stable before and during the global covid-19 shock? *Ecol. Economics* 189, 107142.

IPBES (2019a). *Global assessment report of the intergovernmental science-policy platform on biodiversity and ecosystem services*. Eds. H. T. Ngo, E. S. Brondízio, J. Settele and S. Díaz (Bonn, Germany: IPBES secretariat).

IPBES (2019b). *Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the intergovernmental science-policy platform on biodiversity and ecosystem services*. Eds. S. Díaz, J. Settele, E. S. Brondízio, H. T. Ngo, M. Guèze, J. Agard, A. Arneth, P. Balvanera, K. A. Brauman, S. H. M. Butchart, K. M. A. Chan, L. A. Garibaldi, K. Ichii, J. Liu, S. M. Subramanian, G. F. Midgley, P. Miloslavich, Z. Molnár, D. Obura and A. Bonn (Germany: IPBES secretariat). doi: 10.1111/padr.12283

Knief, U., and Forstmeier, W. (2021). Violating the normality assumption may be the lesser of two evils. *Behav. Res. Methods* 53 (6), 2576–2590. doi: 10.3758/s13428-021-01587-5

Legagneux, P., Casajus, N., Cazelles, K., Chevallier, C., Chevrinais, M., Guéry, L., et al. (2018). Our house is burning: Discrepancy in climate change vs. biodiversity coverage in the media as compared to scientific literature. *Front. Ecol. Evol.* 5. doi: 10.3389/fevo.2017.00175

Leonard, A. F., Zhang, L., Balfour, A. J., Garside, R., Hawkey, P. M., Murray, A. K., et al. (2018). Exposure to and colonisation by antibiotic-resistant e. coli in UK coastal water users: Environmental surveillance, exposure assessment, and epidemiological study (Beach bum survey). *Environ. Int.* 114, 326–333. doi: 10.1016/j.envint.2017.11.003

Lindequist, U. (2016). Marine-derived pharmaceuticals - challenges and opportunities. *Biomol Ther.* 24 (6), 561–571. doi: 10.4062/biomolther.2016.181

Lloret, J. (2010). Human health benefits supplied by Mediterranean marine biodiversity. *Mar. pollut. Bull.* 60 (10), 1640–1646. doi: 10.1016/j.marpolbul.2010.07.034

Lüdecke, D., Ben-Shachar, M. S., Patil, I., and Makowski, D.. (2020). Extracting, computing and exploring the parameters of statistical models using r. *J. Open Source Software* 5 (53), 2445. doi: 10.21105/joss.02445

Madarcos, J. R. V., Creencia, L. A., Roberts, B. R., White, M. P., Nayoan, J., Morrissey, K., et al. (2021). Understanding local perceptions of the Drivers/Pressures on the coastal marine environment in palawan, Philippines. *Front. Mar. Sci.* 8. doi: 10.3389/fmars.2021.659699

Marselle, M. R., Hartig, T., Cox, D. T., De Bell, S., Knapp, S., Lindley, S., et al. (2021). Pathways linking biodiversity to human health: A conceptual framework. *Environ. Int.* 150, 106420. doi: 10.1016/j.envint.2021.106420

Martín-López, B., Montes, C., and Benayas, J. (2007). The non-economic motives behind the willingness to pay for biodiversity conservation. *Biol. Conserv.* 139, 67–82. doi: 10.1016/j.biocon.2007.06.005

MEA (2005). *Ecosystems and human well-being: Synthesis* (Washington, DC: Island Press). doi: 10.5822/978-1-61091-484-0_1

Morgan, M. G., Fischhoff, B., Bostrom, A., and Atman, C. J. . (2002). *Risk communication: A mental models approach* (Cambridge/New York: Cambridge University Press).

Nash, K. L., Cvitanovic, C., Fulton, E. A., Halpern, B. S., Milner-Gulland, E. J., Watson, R. A., et al. (2017). Planetary boundaries for a blue planet. *Nat. Ecol. Evol.* 1 (11), 1625–1634. doi: 10.1038/s41559-017-0319-z

Nawrotzki, R. J. (2012). The politics of environmental concern: A cross-national analysis. *Organ. Environ.* 25 (3), 286–307. doi: 10.1177/1086026612456535

Olver, J. M., and Mooradian, T. A. (2003). Personality traits and personal values: a conceptual and empirical integration. *Pers. Individ. Dif.* 35 (1), 109–125. doi: 10.1016/S0191-8869(02)00145-9

Papathanasopoulou, E., White, M. P., Hattam, C., Lannin, A., Harvey, A., and Spencer, A.. (2016). Valuing the health benefits of physical activities in the marine environment and their importance for marine spatial planning. *Mar. Policy* 63, 144–152. doi: 10.1016/j.marpol.2015.10.009

Pauly, D., Watson, R., and Alder, J. (2005). Global trends in world fisheries: impacts on marine ecosystems and food security. *Philos. Trans. R. Soc. B: Biol. Sci.* 360 (1453), 5–12. doi: 10.1098/rstb.2004.1574

Poortinga, W., Whitmarsh, L., Steg, L., Böhm, G., and Fisher, S.. (2019). Climate change perceptions and their individual-level determinants: A cross-European analysis. *Global Environ. Change* 55, 25–35. doi: 10.1016/j.gloenvcha.2019.01.007

R Core Team (2021). *R: A language and environment for statistical computing* (Vienna, Austria: R Foundation for Statistical Computing). Available at: https://www.r-project.org/.

Ressurreição, A., Gibbons, J., Kaiser, M., Dentinho, T. P., Zarzycki, T., Bentley, C., et al. (2012). Different cultures, different values: The role of cultural variation in public's WTP for marine species conservation. *Biol. Conserv.* 145, 148–159. doi: 10.1016/j.biocon.2011.10.026

Roberts, B. R., White, M. P., Davison, S. M.C., McMeel, O., Eatock, C., Kellett, P., et al. (2021). Public preferences for policy intervention to protect public health from maritime activities: A 14 European country study. *Global Environ. Change* 71, 102397. doi: 10.1016/j.gloenvcha.2021.102397

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S. III, Lambin, E., et al. (2009). Planetary boundaries: Exploring the safe operating space for humanity. *Ecol. Soc.* 14 (2), 32. doi: 10.5751/ES-03180-140232

Román, C., Borja, A., Uyarra, M. C., and Pouso, S.. (2022). Surfing the waves: Environmental and socio-economic aspects of surf tourism and recreation. *Sci. Total Environ.* 826, 154122. doi: 10.1016/j.scitotenv.2022.154122

Roxburgh, T., Ellis, K., Johnson, J., Baldos, U. L., Hertel, T., Nootenboom, C., et al. (2020) *Global futures: Assessing the global economic impacts of environmental change to support policy-making. summary report*. Available at: https://www.wwf.org.uk/globalfutures.

Schielzeth, H., Dingemanse, N. J., Nakagawa, S., Westneat, D. F., Allegue, H., Teplitsky, C., et al. (2020). Robustness of linear mixed-effects models to violations of distributional assumptions. *Methods Ecol. Evol.* 11 (9), 1141–1152. doi: 10.1111/2041-210X.13434

Secretariat of the Convention on Biological Diversity (2020). *UN Global biodiversity outlook 5* (Montreal). Available at: https://www.cbd.int/gbo/gbo5/publication/gbo-5-en.pdf.

Soutter, A. R. B., Bates, T. C., and Mõttus, R. (2020). Big five and HEXACO personality traits, proenvironmental attitudes, and behaviors: A meta-analysis. *Perspect. psychol. Sci.* 15 (4), 913–941. doi: 10.1177/1745691620903019

Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M., et al. (2015). Planetary boundaries: Guiding human development on a changing planet. *Science* 347 (6223), 1259855. doi: 10.1126/science.1259855

Strain, E. M. A., Alexander, K. A., Kienker, S., Morris, R., Jarvis, R., Coleman, R., et al. (2019). Urban blue: A global analysis of the factors shaping people's perceptions of the marine environment and ecological engineering in harbours. *Sci. Total Environ.* 658, 1293–1305. doi: 10.1016/j.scitotenv.2018.12.285

Teh, L. C. L., and Sumaila, U. R. (2013). Contribution of marine fisheries to worldwide employment. *Fish Fisheries* 14 (1), 77–88. doi: 10.1111/j.1467-2979.2011.00450.x

Tingley, D., Yamamoto, T., Hirose, K., Keele, L., and Imai, K.. (2014). mediation : R package for causal mediation analysis. *J. Stat. Software* 59 (5), 1–38. doi: 10.18637/jss.v059.i05

UN (2015) *Transforming our world: the 2030 agenda for sustainable development*. Available at: https://sdgs.un.org/2030agenda.

United Nations (2021a). *The second world ocean assessment* Vol. I (United Nations publication), 570.

United Nations (2021b). *The second world ocean assessment* Vol. II (United Nations publication), 520.

United Nations (2021c). *Intergovernmental conference on an international legally binding instrument under the united nations convention on the law of the Sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction*. Available at: https://www.un.org/bbnj/ (Accessed 11 August 2021).

Valderrama, D., Hishamunda, N., and Zhou, X. (2010). *Estimating employment in world aquaculture* Vol. 45 (FAO Aquaculture Newsletter), 24–25.

Van Liere, K. D., and Dunlap, R. E. (1980). The social bases of environmental concern: A review of hypotheses, explanations and empirical evidence. *Public Opin. Q.* 44 (2), 181–197. doi: 10.1086/268583

White, M. P., Weeks, A., Hooper, T., Bleakley, L., Cracknell, D., Lovell, R., et al. (2017). Marine wildlife as an important component of coastal visits: The role of perceived biodiversity and species behaviour. *Mar. Policy* 78, 80–89. doi: 10.1016/j.marpol.2017.01.005

Whitmarsh, L., and Corner, A. (2017). Tools for a new climate conversation: A mixed-methods study of language for public engagement across the political spectrum. *Global Environ. Change* 42, 122–135. doi: 10.1016/j.gloenvcha.2016.12.008

Wolsko, C., Ariceaga, H., and Seiden, J. (2016). Red, white, and blue enough to be green: Effects of moral framing on climate change attitudes and conservation behaviors. *J. Exp. Soc. Psychol.* 65, 7–19. doi: 10.1016/j.jesp.2016.02.005

WHO (2015). *Connecting global priorities: Biodiversity and human health, a state of knowledge review* (World Health Organization and Secretariat of the Convention on Biological Diversity), 364.

WHO (2021). *Nature, biodiversity and health: An overview of interconnections* (Copenhagen: WHO Regional Office for Europe; Licence), 42.

World Wildlife Fund (2018). *Living planet report - 2018: Aiming higher*. Eds. M. Grooten and R. E. A. Almond (Switzerland: Gland).

Zelezny, L. C., Chua, P.-P., and Aldrich, C. (2000). Elaborating on gender differences in environmentalism. *J. Soc. Issues* 56 (3), 443–457. doi: 10.1111/0022-4537.00177\