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RESEARCH ARTICLE

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We may not know much about the deep sea, but do we care about mining it?

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Abstract

1. The way we value the environment affects how we treat it. While public awareness of human impacts on the ocean is increasing, industrial activities in the deep sea are accelerating rapidly and out of sight.
2. The underlying values we hold for the environment were increasingly recognised as an important factor in environmental decision-making, and it was thus important to evaluate public values towards deep-sea environments.
3. Here, we explored people's care for the deep sea and related this to the perceived risks of seafloor mining by comparing the deep sea to three other remote environments: Antarctica, remote terrestrial environments and the Moon.
4. We conducted an online survey to investigate symbolic values, which we define as the emotions, moods and meanings an environment evokes, as an element affecting people's care for the environment. In addition, we investigated the respondent's knowledge, worldviews and the perceived environmental and societal risk of mining in these four environments.
5. We found that symbolic values shape people's environmental care and that the overall symbolic value attributed to each of the environments differs.
6. People perceived it likely that mining will take place in the deep sea, and the majority of respondents (81%) stated to care a lot or very much about human activities harming the deep sea.
7. In comparison to the other remote environments, in a general sense people cared less about the deep sea, and their self-assessed knowledge of the deep sea was lower.
8. These results suggest that it was fundamental to account for the underlying values and emotions towards the environment when evaluating the risks of human activities in remote settings.
9. Our results further highlighted the need to improve public understanding and connection with the deep sea and its role within wider society to engender deep-sea stewardship.

KEYWORDS

deep-sea mining, environmental meanings, remote environments, risk perceptions, stewardship, symbolic values

1 | INTRODUCTION

Economic development and human activities in the ocean are accelerating rapidly. With an already crowded coastal zone and inshore area, an increasing number of maritime activities[1] are moving to the deep sea. Old and new maritime activities are the subject of many government, research and industry initiatives to grow the 'Blue Economy' (Lee et al., 2020), and the deep sea is being promoted as the new frontier for resource extraction (Hein et al., 2013; Kung et al., 2020; Petersen et al., 2016). The deep sea is the largest ecosystem on the planet (Thiel, 2003), yet it is far from all but a handful of people (Childs, 2019a) and has long been considered out of sight, out of mind. While this invisibility and the remoteness of the deep sea have enabled it to be framed as an uncontentious space for exploitation (Hannigan, 2016), out of sight may not mean people do not emotionally invest in protecting the environment of this remote ecosystem and care for it.

Fast advancing technologies have now granted access to even the deepest parts of the ocean, fuelling interest in commercial exploration of deep-sea resources, such as metals and rare earth elements (Miller et al., 2018). Deep-sea mining (DSM) activities are currently planned in the economic zones of several national jurisdictions, particularly Pacific Island States, and in areas beyond national jurisdiction (Jaeckel, 2019; Smith, 2018). The world's first commercial DSM operation for extracting copper and gold was planned for waters off Papua New Guinea. A subject of controversy and community resistance since its initiation (Childs, 2019a), the mining initiative came to a halt in 2019 due to the developer's financial problems (PwC, 2019). In a more experimental setting, the Japan Oil, Gas and Metals National Corporation completed a DSM trial in Japanese waters in 2017 (JOGMEC, 2018).

Even though much is unknown about the deep sea, the past decades have seen an increasing effort to map the impacts of human activities on the deep-sea environment (Ramirez-Llodra et al., 2011). While the risks of deep-sea activities have been considered mainly through environmental impacts (Koschinsky et al., 2018; Weaver et al., 2018), there are many economic (e.g. financial, investment) and social (e.g. norms, values) risks that have yet to be adequately framed (Childs, 2018; Hoyt et al., 2017).

Public perceptions of maritime activities and the combined risks they pose can significantly influence the political and regulatory processes that underpin the development of these activities (Gelcich et al., 2014; Lotze et al., 2018). The societal acceptance of maritime developments is affected by the perceived risks (Mason et al., 2010) which will affect whether social license[2] is obtained or not (Kelly et al., 2017; Voyer & van Leeuwen, 2019). Risk perceptions and information further influence concern over environmental impacts and affect decision-making (Wachinger et al., 2013).

People's personal values and worldviews play a key role in shaping their perceptions of the acceptability of activities, and their expectations regarding emerging maritime industries are likely to affect their future development (Voyer & van Leeuwen, 2019). Accounting for the underlying values we hold for the environment is increasingly recognised as an important factor in environmental decision-making, encompassing also the deeper emotions and symbolic meanings we attribute to specific settings (Böhm & Pfister, 2008; Vining & Tyler, 1999; Williams et al., 1992). However, most current approaches assume that values are informed by experiential and rational ways of relating to environments, and the symbolic meanings and emotions associated with the oceans that shape our relationship with the environment have been little explored (Gee, 2019; Kearns & Collins, 2012; Šunde, 2008). In the light of the increased development of offshore activities and their sometimes controversial nature, it is timely to evaluate the contribution of these values to people's emotional attachment to the deep sea to support governance of deep-ocean space and resources (Geller, 1995).

Here, we explore people's care for the deep sea through the symbolic value people attribute to deep-sea environments and what this means in terms of potential future mining activities. We conduct an online survey to explore the concept of environmental care in relation to the deep sea through measuring: (a) the emotions, moods and meanings (symbolic values) the environment evokes (Bruner & Postman, 1948; Cole, 2005), (b) the personal values and worldviews people hold, (c) their perceptions of environmental and social risk and (d) their self-assessed knowledge. We compare DSM to mining in three other remote environmental settings (the Moon, remote terrestrial environments and Antarctica) to gain additional insights on the role of accessibility and remoteness on environmental care.

1.1 | Environmental care

A central concept in our research is people's care about mining activities taking place in the four different environments, which we measure by means of rating scale. People's care about the environment (i.e. their protectiveness towards it) is often interlinked with their concern for the environment (i.e. their worry about it) which is affected by the meanings they attribute to it (Brehm et al., 2013). While care and concern are intertwined constructs that are often used interchangeably, care incorporates a measure of emotional connection (Perkins, 2010) and is often defined as an *affective concern*, that is, experiencing concern through emotion, feeling and mood (Buch, 2015).

Caring for and about nature may further be viewed as the attribution of value to an environment (Klain et al., 2017). Present discourse recognises multiple values that may be assigned to an environment, ranging from intrinsic (existence) and instrumental (use) values to relational values (Chan et al., 2016; Pascual et al., 2017; Tadaki et al., 2017). The notion of relational values, in particular, explains how and why environments matter to people by accounting for the diverse relationships people have with natural environments (Gould

[1]Because the topic of our research is exploitation of the deep sea, we use maritime to refer to activities in the marine environment. Reference to maritime, however, does not exclude marine activities which relate more clearly to exploitation of the biological resources of the seas.

[2]Social acceptability = a social licence, and they are used interchangeably.

FIGURE 1 Factors contributing to environmental care considered in this study. Our focus is on the role of symbolic values people attribute to different environments

et al., 2015). Previous studies on how people value deep-sea environments have focussed on the instrumental and intrinsic values, through the economic valuation of deep-sea goods (Aanesen et al., 2015; Jobstvogt et al., 2014) and perceptions of specific species and habitats (Ankamah-Yeboah et al., 2020; Zanoli et al., 2015). However, given that these diverse assigned values are often examined on the basis of relational dimensions through people's relationships with specific places or rely on one's previous knowledge of an environment (Engel et al., 2020; Voyer et al., 2015), these approaches are not well-suited for studying values and perceptions of remote and unfamiliar environments. Consequently, in this study, we focus on the emotional dimensions of more general underlying values associated with an environment, which we assume can further illuminate the attribution of specific values, including care (Šunde, 2008).

To focus on the emotional dimension of care, we explore people's affective responses[3] by measuring the symbolic values people attribute to the different environments (Figure 1). We conceptualise symbolic

[3]The different types of emotional values (moods, feelings and emotions) and meanings associated with an environment contribute to its symbolic value (signifying the immaterial value attributed to it). We use the word symbolic value throughout in the manuscript.

TABLE 1 Characteristics of the different environments considered in this study

	Antarctica	Deep sea	The Moon	Remote terrestrial environments
Mining interest	Proposed in theory	Proposed	Proposed in theory	Ongoing
Accessibility	Possible	Difficult	Difficult	Possible
Governance regime	Antarctic treaty (1959), mining banned	UNCLOS (1982)	Outer Space Treaty (1967) & Moon Treaty (1984)	Country specific
Research effort	Moderate	Low–moderate	Moderate	High
Media attention and public interest[a]	Low–moderate	Low	Moderate–high	High

[a]Google Trends comparison between terms 'Deep sea', 'Antarctica' and the 'Moon' for the past 5 years world-wide (Google, 2020).

values as the emotions and meanings the environment represents, relevant not primarily to itself, but how we view and value it (Bruner & Postman, 1948). In comparison to more place-specific (relational) views of environmental values, we define symbolic values as more general to certain types of environments, but untied to a specific place. We hypothesise that these values can shed light on whether people care about environments that will be affected by mining activities.

Accounting for affective responses widens our understanding of what makes people take action when an environment or its quality changes. As mentioned above, people experience and interpret the environment through their emotions (Appleton, 1998) and their care and actions are linked. The well-being of nature is dependent on good stewardship which is connected to caring for the environment (Nassauer, 1997). Caring or not caring about an environment and its state can thus be related to whether we will take action to protect it or not (Clayton, 2003; Jones et al., 2016), and environmental care connotes the practical action of caring for nature (Buch, 2015). While limited systematic attention has been dedicated to exploring how environmental care drives action (Jax et al., 2018), caring about nature is considered a key dimension of environmental stewardship (Enqvist et al., 2018).

Environmental care is also impacted by people's perceptions of risk posed by an activity. We conceptualise risk perception as the perceived probability of negative consequences to the environment and society from a specific activity (O'Connor et al., 1999). We measure risk also in terms of the likelihood of mining activity (Figure 1). Knowledge of both the risk factors and what is at risk has been shown to impact people's emotions (affective responses) and cognitive processes (Slovic et al., 2004; Slovic & Slovic, 2013; Sobkow et al., 2016). Actively caring about an issue requires people to be informed about it (Figure 1) in terms of the environment itself and the activities that take place (Clayton & Myers, 2015). However, people's emotional connection to nature is suggested to be more important in contributing to care than just literacy (Lumber et al., 2017).

Apart from the impact of symbolic values, risk perception and knowledge on environmental care, people's personal values and environmental attitudes are also a key consideration (Figure 1). The reason is that the broad values we hold[4] underpin our preferences and affect our behaviour (Fulton et al., 1996; Vaske & Donnelly, 1999). In this context values are concepts or beliefs about desirable end states or behaviours (Schwartz & Bilsky, 1990), and the role of values in explaining pro-environmental behaviours and attitudes has been thoroughly explored (Schultz et al., 2005; Steg et al., 2014; Ünal et al., 2018).

1.2 | The environmental setting

While symbolic meanings and emotions towards the environment are recognised as an important factor for environmental care, they are usually evaluated in specific local settings or places (Williams et al., 1992). In our research, we investigate global environments that go beyond local settings. As many mining activities occur far from humans in remote environments, measuring people's care of environmental impacts in relatively unfamiliar and remote settings cannot rely on experiential measures. This raises the question whether it is reasonable to assume environmental care for places not visited (Brehm et al., 2006). We believe in this sense environmental care is somewhat analogous to the concept of place attachment (Kaltenborn, 1998) which can grow as a consequence of person-specific emotional responses (van Putten et al., 2018) that are independent of any location-specific experience.

Other remote environments offer an analogy to examining perceptions of DSM in a broader context. In this study, we use Antarctica, remote terrestrial environments and the Moon as sentinels for examining public perceptions of DSM. We intended for these comparatives to be similar yet different on several dimensions (Table 1).

[4]These broad universal values are distinct from the specific attributed values (intrinsic, instrumental and relational) discussed above.

Most research pertaining to mining is conducted for the terrestrial environments. Mining activities in some of these environments are ongoing, with certain similarities and differences in the environments in terms of their governance regime, accessibility and assumed public knowledge. Apart from terrestrial environments, all of these environments and the resources within them are considered common heritage of humankind, and the comparison of the deep sea, space and Antarctica is not a new one (e.g. Frakes, 2003; Kirkham et al., 2020; Nicholson, 2002). Through this comparison, we provide insight into people's environmental care and how this relates to the potential harmful impacts of extractive activities in the deep sea (and compare this to three other remote environments), and provide useful knowledge to anticipate any actions that might impact the development of a sustainable Blue Economy.

2 | METHODS

2.1 | Survey design and materials

To explore the symbolic value people attribute to the deep sea, Antarctica, remote terrestrial environments and the Moon, an online survey was conducted in April–July 2019. Given the international nature of the governance of these areas, an online survey was the preferred method that would allow us to reach as many people in different countries and demographic groups as possible. The survey was administered using an open-source platform Limesurvey, and was available in English, French and Finnish.[5] The survey was tested on three to five respondents in all three languages prior to its distribution.

To reach a broad audience, the survey was distributed through different social media platforms and email lists. The distribution was facilitated by university email lists targeting researchers, students and employees in several major universities in Finland and Australia, as well as public and private societies. To reach more non-academic people who may have different backgrounds and interests (including mining specifically), these societies included senior members' societies (Lions club, Rotary club) and geology societies.

The survey contained a total of 27 questions on seven items of interest: environmental care, symbolic values, environmental and societal perceptions of risk of mining, knowledge of the environment and human activities, and the perceived likelihood of mining in the future (for full survey outline, see Supporting Information S1). To measure environmental care, we asked respondents how much they would care about something bad happening to the environment, whereas the environmental and societal risks were defined specifically through mining activities. The reason for separating environmental and societal risk in the survey was that we did not want to assume that perception of the overall risk of an activity would be governed by the environmental damage. Appreciating that there are multiple definitions of risk, we did not specify the reasons why people would find an activity societally risky—whether it would be economically, high risk on human safety, through degradation of the environment, or other reasons.

For each environment, a brief definition of the environment and three images were presented (Supporting Information S1). To avoid anchoring respondents to specific species or places, images were selected to not portray humans or animals. Prior to answering the questions, participants were informed about the background and broad aims of the survey. All participants remained anonymous. The survey materials stated that participation was entirely voluntary and that respondents may stop the survey at any time, so by filling out the survey participants indicated their consent. Ethical approval for this study was obtained from the University of Helsinki Ethical Review Board in Humanities and Social and Behavioural Sciences (registration 01/2019).

To examine the emotions, moods and meanings people hold for remote environments, we constructed a symbolic value typology drawing on previous typologies examining environmental values from more experience-based and utilitarian perspectives (Brown & Raymond, 2007; Brown & Reed, 2000; Kellert, 1993, 1997). We also included words that had been mentioned in previous studies concerning public perceptions of the sea (e.g. Jefferson et al., 2015) and found antonyms to these words. The final symbolic value typology contained eight items (Table 2) and respondents were asked to answer using a 7-point scale to rate to what extent they would use a certain value item to describe the environment in question.

To account for the respondents' personal values and worldviews, we included an environmental portrait-value-questionnaire (Bouman et al., 2018) based on Schwartz's value typology (Schwartz, 1992, 1994), as well as the 15-item New Ecological Paradigm (NEP) as a measure of broad pro-environmental beliefs (Dunlap & Van Liere, 1978; Dunlap et al., 2000). Respondents were asked to indicate their opinion for each of the item statements in the PVQ and NEP using a 7-point Likert type scale, ranging from 1 strongly disagree to 7 strongly agree. Environmental and social risk perceptions of mining were evaluated on a 5-point scale from 'not at all risky' to 'very risky'. Knowledge of the environment and the human activities there were evaluated on a 5-point scale from 'nothing' to 'very much'. We further included several questions to account for the socio-demographic factors in the survey responses. The internal consistency of the responses was tested with Cronbach's alpha (Cronbach, 1951).

2.2 | Statistical analyses

We checked for statistical differences between all survey items for gender, age, education, country and place of residence using chi-squared tests. To examine the difference in responses between different socio-demographic factors, we calculated the mean response for each variable of interest for the four environments. We then tested for statistically significant differences between the responses for each response variable using a Kruskal–Wallis test. A Mann–Whitney *U* test was applied for pairwise comparison between the

[5]The first author resides in Finland hence the Finnish language survey, the second author resides in Australia.

TABLE 2 Symbolic values used to measure affective response towards the different environments (measured on a 7-point scale)

Symbolic value	Brief (one sided) description of value	Item (7-point scale with midpoint meaning neutral score)
Aesthetic	A value elicited through the appreciation of nature	Ugly–Beautiful
Intrinsic	The value nature has in its own right and not through human uses	Insignificant–Important
Serenity	Nature's ability to provide peace, calm and tranquillity	Stressful–Calm
Abundance	Nature's ability to provide a quantity or supply of life	Empty–Abundant
Spirituality	The special value of nature-for the human spirit or soul	Ordinary–Mystical
Excitement	Enthusiasm and energy created by the characteristics of an environment	Boring–Exciting
Attraction	A preference for the natural environment	Repelling–Inviting
Relaxation	Nature's influence on people's mood and feelings of happiness and relaxation	Scary–Relaxing

four environments by testing the similarity of distributions between responses. Spearman rank correlation test was applied to assess the relationship between ordinal numeric variables.

Conditional dependencies between general worldviews and values, symbolic values, care for environments and risk perceptions were examined with Bayesian networks (BNs). BNs are graphical representation of a multivariate joint probability distribution of a set of variables, in which the nodes of the network correspond to the variables and the edges depict the direct probabilistic dependencies between variables. Structural learning algorithms for BNs enable the exploration of the data structure and to gain insight into the most relevant connections between variables (Barber, 2012). An algorithm-learnt BN can be seen as a lower dimensional representation of the data, which retains the strongest dependencies in the data, accounting also for associations between multiple variables, while abstracting out weak correlations (Barber, 2012). BNs can thus be used to understand complex multivariate relationships, offering a more robust method to evaluate dependencies between multiple variables than simple linear correlations by accounting for nonlinear connections. Here, we use BNs without implication that the arcs represent causal relationships between variables, and interpret the network to indicate conditional independence relationships and probabilistic properties (Pearl, 2009; Scutari & Denis, 2014).

Prior to structural learning, missing data for any given variable were excluded and continuous values from the NEP score and portrait-value-questionnaire items were transformed into three discrete classes to facilitate learning rates. Multiple thresholds were tested to check if the discretisation changed the overall interpretation of the network structure.

To learn the conditional dependence structure from the data, we applied the hill climbing algorithm using the package BNLEARN (Scutari, 2009) in R (R Core Team, 2020). Bayesian Dirichlet Equivalent (BDe) was used as an optimisation score to be used by the algorithm to learn the most optimal network structure, as it deals better on small sample sizes without penalising network complexity (Nielsen & Jensen, 2009). Structural uncertainty was evaluated with nonparametric bootstrapping with 2,500 samples, as this is deemed the number of samples needed for robust estimation for features with a true probability close to the threshold (Broom et al., 2012). After network learning, the obtained network and their edges were evaluated with Bayesian information criteria (BIC). We used a default threshold of 0.7 for arc significance, meaning that only arcs that appeared in 70% of the networks were retained in the final averaged network. An exception to the 70% threshold was the network for the Moon, which received a higher BIC score with the threshold of 0.68. In addition, we recorded the algorithm-derived significance thresholds for each network, although many of these were below 50% confidence. All analyses were performed in R 3.6.1 (R Core Team, 2020). The analysis scripts and data are available on GitHub (https://github.com/lkaikkonen/DeepSeaValues).

3 | RESULTS

We received a total of 706 responses to the online survey. Some surveys were incomplete and not included in the sample, leaving a total of 579 useable survey responses that were included in the analysis. Three hundred and forty respondents were female and 210 were male (Table 4). The sample contained a high number of young adults, with 58% of respondents between ages 18% and 35%, and 39% between 36 and 65 years. A high proportion of the respondents (86%) had at least an undergraduate-level education. The survey distribution approach which was through social media

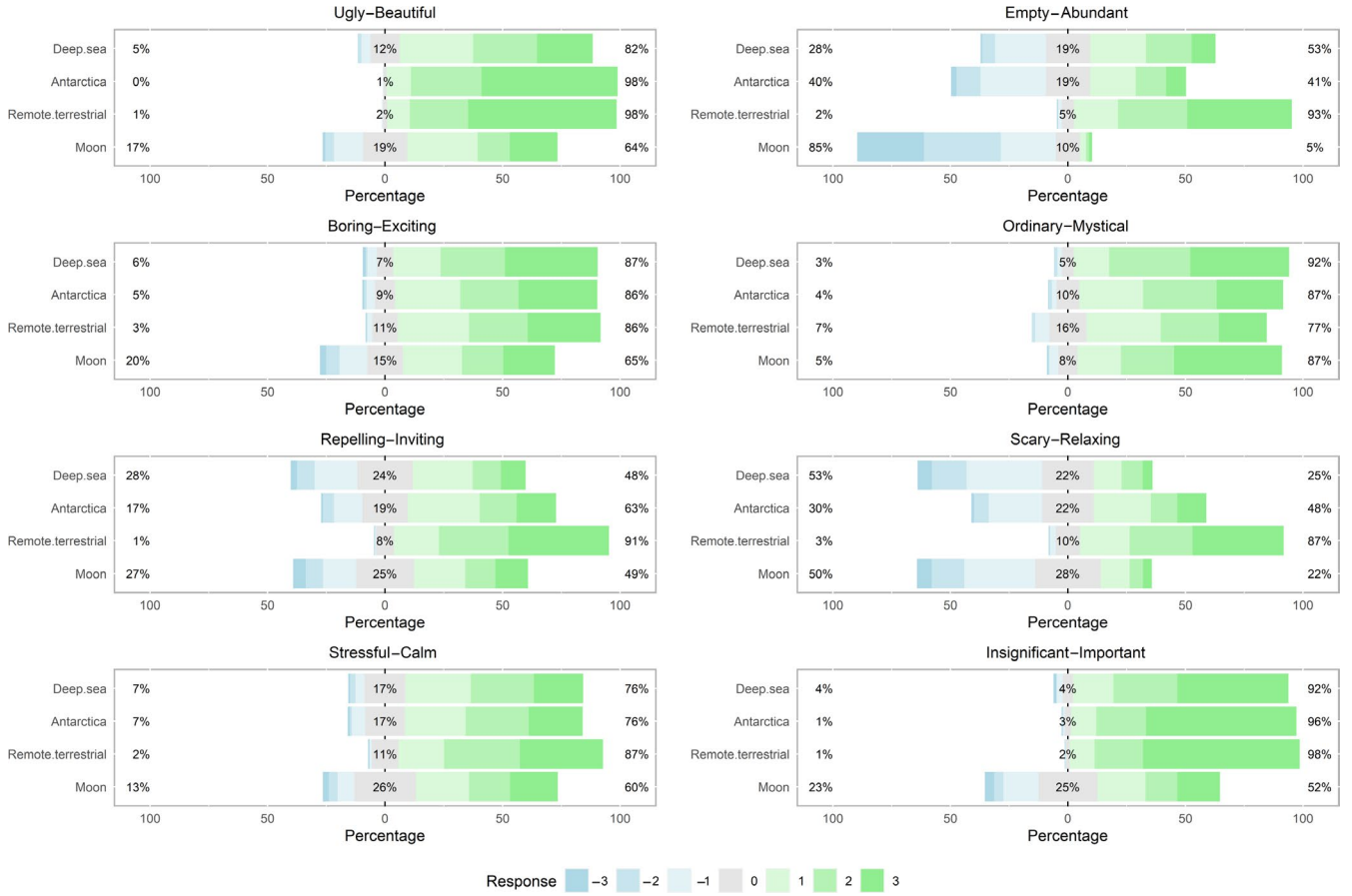

FIGURE 2 Symbolic values attributed to four different remote environments on a 7-point scale from −3 to 3, with an opposite semantic descriptor at either end of the scale. Percentages indicate the summed proportion of responses attributed to either side of the two extremes, expressed in positive values (green), negative scores (blue) and middle scores (grey). The mid score is interpreted as a neutral score and the percentage is shown in the middle of each of the eight graphs

platforms and university mailing list both led to the high number of young respondents and the relatively high education level in our study. Moreover, we received answers from 37 countries, but most respondents (68%) were living in Finland (Table S2). This is also likely due to the study originating in Finland and most social and professional connections being available in this country that would have facilitated survey distribution. We are cognisant that there may be sampling bias and our sample is not representative of the population in Finland or any other respondent countries, and we qualify the insights gained as such.

3.1 | Symbolic values for the environments

We used eight positive and negative symbolic values (Table 2) to measure affective response for the deep sea and the three other environments (Figure 2).

There were few negative responses to the aesthetic values ascribed to the deep sea (82% were positive). However, Antarctica and remote terrestrial environments did not receive any negative responses for the aesthetic values and all respondents considered these as beautiful. This was not the case for the Moon (64% negative). The deep sea was assigned high scores for its intrinsic value, similar to Antarctica and the terrestrial environments (Figure 2, panel 8).

Although the difference is small, the deep sea was considered the most exciting of the four environments. Simultaneously, the deep sea had the highest rates of responses for being repelling and scary, similar to the Moon. The deep sea was considered more abundant than Antarctica. The Moon is quite different to the other remote environments in terms of five of the eight emotional responses (aesthetics, abundance, excitement, serenity and intrinsic; Figure 2).

When we combine each of the eight emotional responses, we get an overview of the positive or negative tendency for the symbolic values associated with the deep sea and the other three remote environments (Figure 3).

The symbolic values associated with the deep sea (median score 1.125) were less positive than values associated with Antarctica (median score 1.375, Kruskal–Wallis test $p < 0.001$). The highest overall value scores (most positive) were associated with terrestrial environments, and the lowest (most negative) with the Moon (Figure 3). The symbolic value scores were statistically significant between all four environments (Kruskal–Wallis test, $p < 0.001$) meaning that the overall emotional response to each of the remote environments is different.

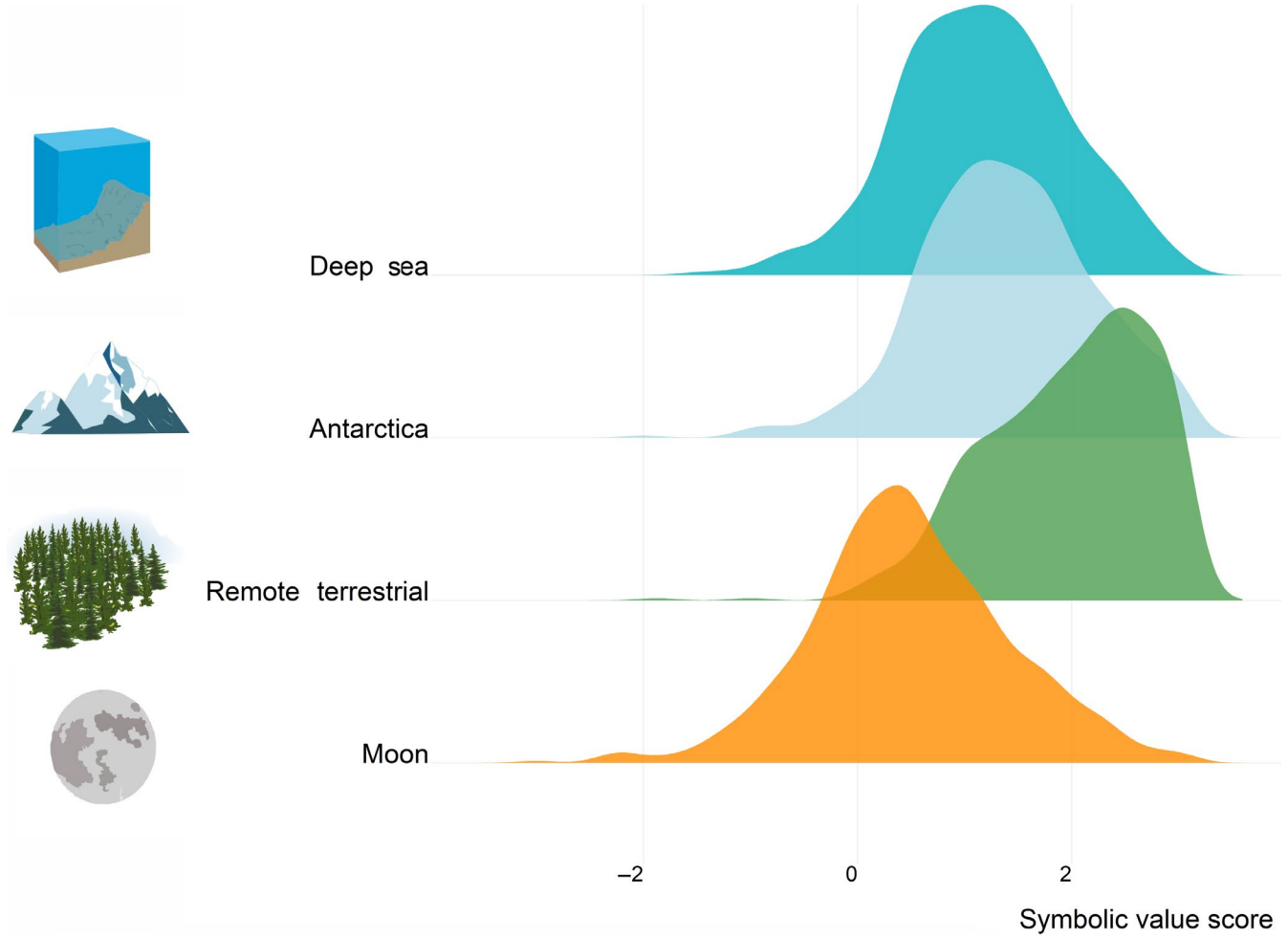

FIGURE 3 Distribution of the respondents' symbolic value scores for the different environments (scores greater than 0 indicate positive symbolic values)

3.2 | Risk perceptions and knowledge

The survey collected data on the perceived environmental and social risk of mining in the deep sea (and the three other remote environments). The reason for assessing both environmental and societal risk was to get a more comprehensive view of the perceived risks of mining activities, while not presuming they were linked. Over 80%, the respondents rated the environmental risk of mining high or very high in the deep sea, Antarctica and remote terrestrial environments (Mann–Whitney *U* test, $p = 0.6687$; Figure 4).

The societal risk of mining was similarly considered high, with 73%–76% of respondents evaluating mining activities in the deep sea, remote terrestrial environments and Antarctica as risky to very risky to society. Mining activities on the Moon were perceived significantly different from other environments ($p < 0.001$) and were considered to be less socially and environmentally risky.

Respondents were asked to indicate their level of knowledge about the environment itself as well as their knowledge of human activities that take place in these different environments. Respondents' self-assessed knowledge of the nature and environmental characteristics of the deep sea was significantly lower than the knowledge of Antarctica and remote terrestrial environments (Mann–Whitney *U* test, $p < 0.001$; Figure 4, panel 1). Similarly, little was known about human activities in the deep sea and the Moon, with 54% of respondents stating they know very little to nothing about activities in the deep sea. Concerning knowledge of human impacts, respondents had significantly higher levels of self-assessed knowledge about nature and the environment and human activities in Antarctica and remote terrestrial environments compared to the deep sea and the Moon (Mann–Whitney *U* test, $p < 0.001$).

3.3 | Likelihood of mining activities in the near future

Mining activities were thought to be likely to very likely to take place in the deep sea according to 62% of respondents. Mining activities were perceived significantly more likely to take place in the future in remote terrestrial environments, perhaps because these activities already take place here (Table 2). However, the majority of respondents (57%) indicated that it was also likely to very likely that mining activities would take place in Antarctica (where currently there is

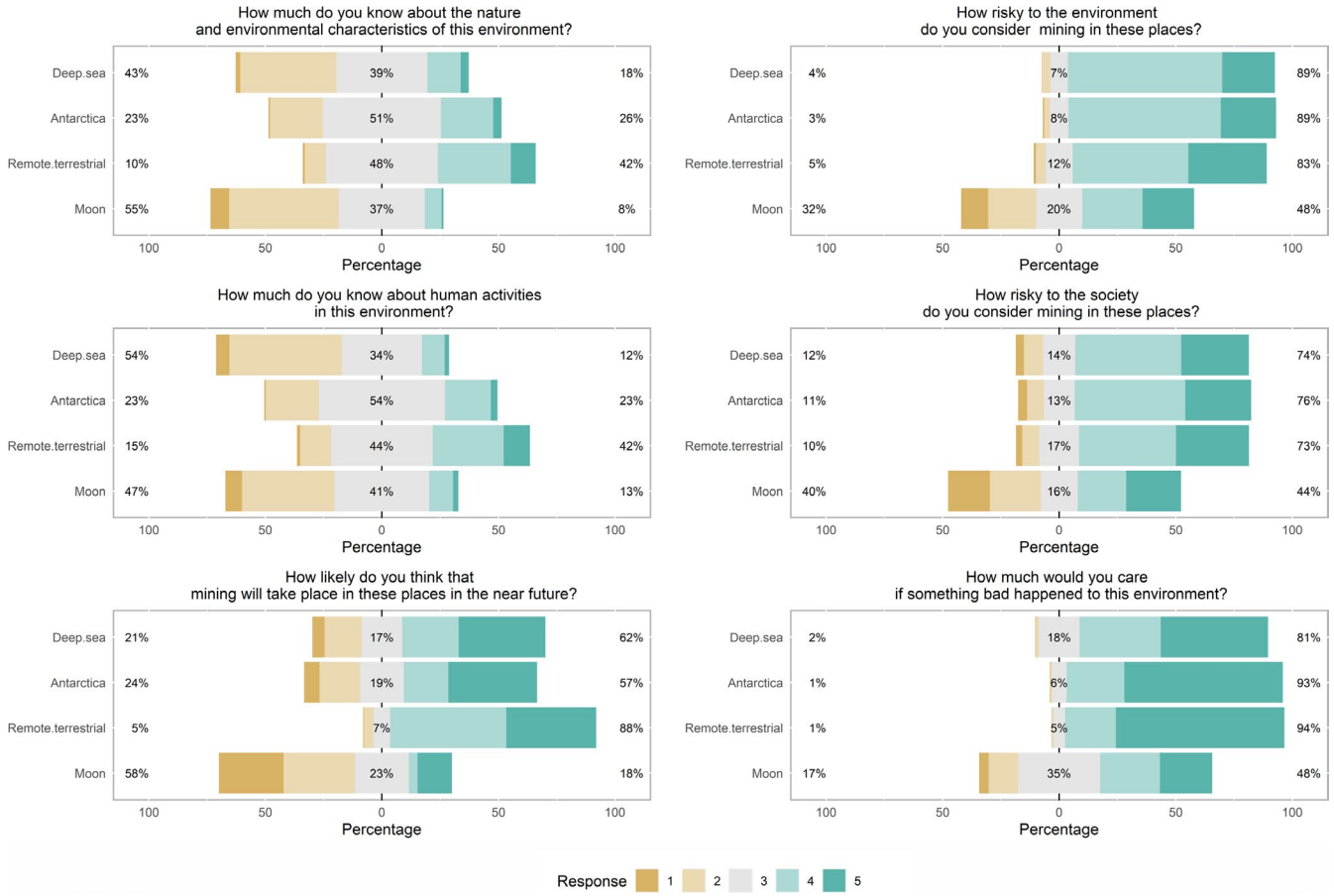

FIGURE 4 Responses from survey items used to quantify perceptions attributed to the four studied environments and perceptions about mining in them. Percentages indicate the summed proportion of responses attributed to either side of the two extremes. The mid score is interpreted as a neutral score and the percentage is shown in the middle of each of the graphs

no mining and mining is explicitly banned). Mining activities were thought to be least likely on the Moon with only 18% of respondents thinking that mining will take place there.

3.4 | Care for the environments

The majority of respondents (81%) stated that they cared a lot or very much about human activities harming the deep sea. However, the proportion of respondents who cared very much or a lot about remote terrestrial environments and Antarctica was significantly higher (over 90%, Mann–Whitney U test, $p < 0.001$). Overall the respondents cared least about the environment on the Moon.

3.5 | Associations between variables

The hill-climbing learning algorithm (Russell & Norvig, 2002) was used to develop a Bayesian network structure to gain insight into the variables that could explain the stated level of care for negative environmental impacts on the four remote environments (Figure 5). We present here only the skeleton of the BN, with no directed edges between variables. While BNs are by definition directed graphs, the direction of the arrow is of less importance than the existence, or rather the non-existence, of a connection between the two variables (Korb & Nicholson, 2010). The network connections can be typified according to the strength of the edges, reflecting how well the network inference learned the true arcs (Figure 5; Table 3).

The strongest links exist between environmental care and the symbolic values. An equally strong link is also apparent between the perception of environmental and societal risk posed by mining activities (Table 3). Knowledge of the environment was linked to the knowledge of human activities. For the deep sea, the perceived likelihood of mining was connected to a respondent's self-assessed knowledge of human activities in the deep sea (with 74.6% confidence).

While all the four networks are technically different, two distinct network structures were best supported by the data, with some subtle differences between them (Table 3). The level of perceived environmental risk is linked to the level of perceived societal risk and subsequently to the level of environmental care. In the responses

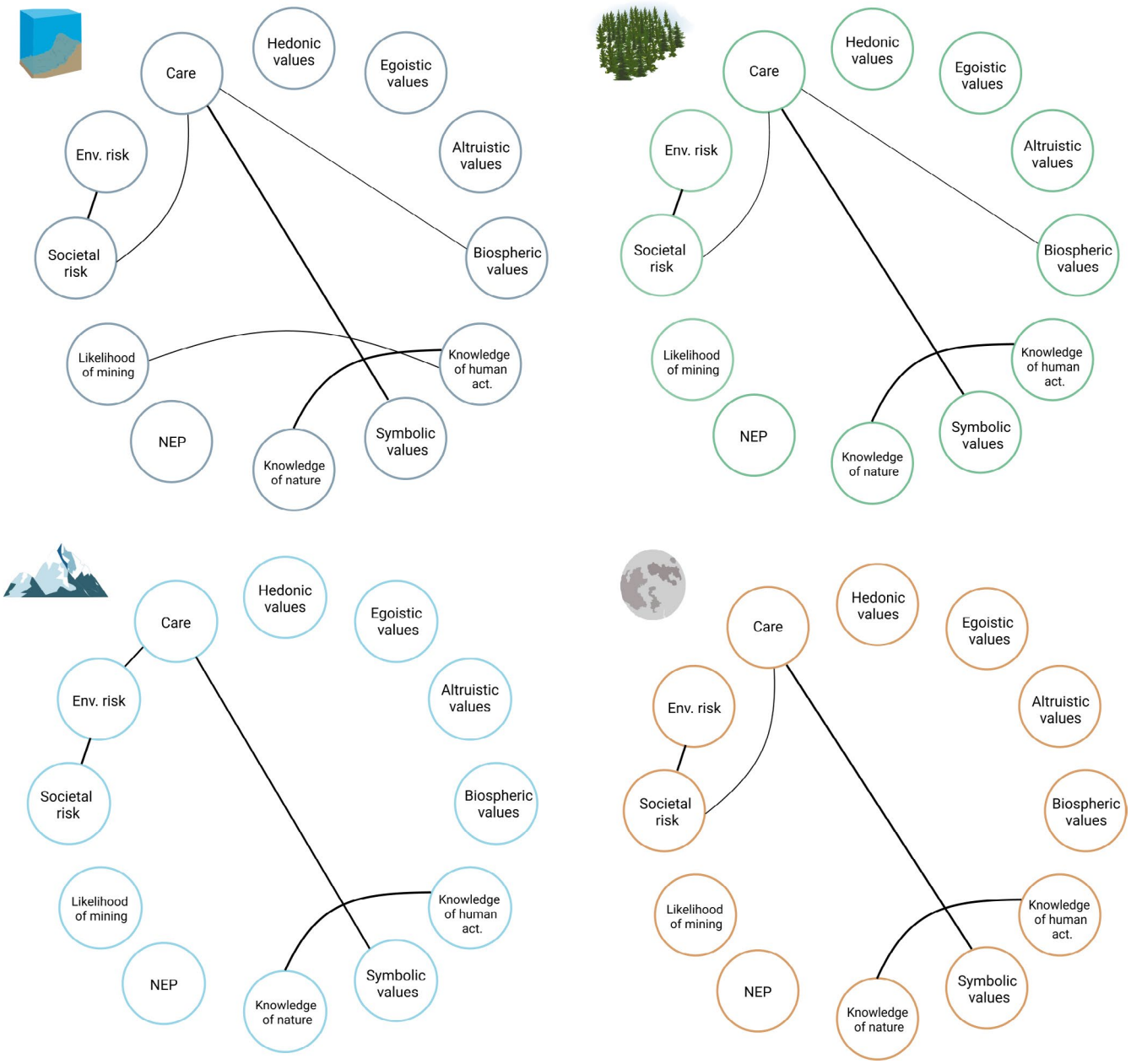

FIGURE 5 Bayesian network structure for the deep sea and three other remote environments with 70% significance thresholds (network redrawn from the outputs of package BNLEARN). Line widths indicate confidence in the conditional dependency relationship (frequency of the edge in the 2,500 bootstrap networks). Conditionally independent variables have no link (edge) to other variables (nodes) in the network

concerning Antarctica the direction was the reverse, environmental care was first connected to the perceived environmental risk, which is then linked to societal risk.

Importantly, and in support of the perspective taken in our study, environmental care was connected to the symbolic values for all four environments. The likelihood of mineral extraction, personal values (altruistic, hedonistic, egoistic) and environmental worldviews (NEP) were all conditionally independent in most of the networks (no edges shown for these variables in Figure 5), with lower confidence in these connections within the networks they appeared in (Table 3).

Some of the connections in the network also showed weaker associations within variables when the significance threshold was lowered (Figure S3). Care for all environments was connected with biospheric values in all environments except for the Moon with 50.6%–78.3% confidence, whereas care and NEP score were connected only in the responses concerning the deep sea with 64.2% confidence. We also tested the conceptual framework using bivariate comparisons between individual symbolic values and environmental care (Table S4). The correlation between the symbolic value score and other variables shows that beauty, excitement and importance

TABLE 3 Bayesian network BIC scores and link strengths for the four remote environments

Network	BIC score	Edge	Confidence
Deep sea	−9598.864	Knowledge of environment—knowledge of human activities	1
		Environmental risk—societal risk	1
		Symbolic value—care for the environment	0.9716
		Societal risk—care for the environment	0.7324
		Care for the environment—biospheric values	0.7116
		Knowledge of human activities—likelihood of mining	0.7460
Antarctica	−9311.906	Knowledge of environment—knowledge of human activities	1
		Environmental risk—societal risk	1
		Symbolic value—care for the environment	0.8988
		—	
		Care for the environment—environmental risk	0.8348
		—	
Remote terrestrial	−9031.955	Knowledge of environment—knowledge of human activities	1
		Environmental risk—societal risk	1
		Symbolic value—care for the environment	0.9916
		Societal risk—care for the environment	0.8672
		Care for the environment—biospheric values	0.7832
		—	
The Moon	−9186.923	Knowledge of environment—knowledge of human activities	1
		Environmental risk—societal risk	1
		Symbolic value—care for the environment	0.9824
		Societal Risk—care for the environment	0.6828
		—	
		—	

of the environment were the most connected to environmental care and risk perceptions (Table S4).

3.6 | Impact of demographics on care, risk, values and knowledge

Gender had a significant effect on responses to the survey questions (Table 4). More specifically, male respondents self-assessed their knowledge of both the environmental characteristics and human activities in all environments to be greater. Male respondents cared less, had more negative emotional responses and perceived the environmental and social risks to be lower (Table 4). In terms of the four environments, differences were largely due to differing responses with regard to the Moon and the deep sea. More detailed comparisons of the effects of socio-demographic factors for each separate environment are presented in the Supporting Information (Tables S5–S8).

Older respondents rated their level of environmental care significantly higher than younger respondents. Education level and country of residence had a significant impact on the respondents' stated environmental knowledge. We adhere this difference partly to the differing number of respondents with a higher education from different countries (S2). Respondents with a postgraduate degree also rated their knowledge of the human activities higher than other respondents.

4 | DISCUSSION

The aim of this study was to explore the symbolic value people attribute to the deep sea and what this means in terms of environmental care and future mining activities. To achieve this, we examined four different domains that in our mind contribute to people's environmental care: symbolic values, environmental and social risk

TABLE 4 The effect of socio-demographic factors on the main variables of interest. Significant interaction between variables from Kruskal–Wallis test (95% confidence interval)

Socio-demographic factor		*n*	Care for environment	Environmental risk of mining	Societal risk of mining	Symbolic value	Knowledge of the environment
Age	18–35 years	333	Significant interaction	No sign. interaction	No sign. interaction	No sign. interaction	No sign. interaction
	36–65 years	226					
	>65 years	13					
	NA	7					
Gender	Female	340	Significant interaction	Significant interaction	Significant interaction	Significant interaction	Significant interaction
	Male	210					
	Other	9					
	NA	20					
Education	Grade 10 or lower	1	No sign. interaction	No sign. interaction	Significant interaction	No sign. interaction	Significant interaction
	High school, vocational/ trade school	69					
	Undergraduate degree	133					
	Graduate degree	216					
	Postgraduate	153					
	NA	7					
Country		See Table S4	No sign. interaction	No sign. interaction	No sign. interaction	No sign. interaction	Significant interaction

perceptions, personal values and worldviews, and knowledge. We compare the deep sea to three other remote environments (the Moon, remote terrestrial environments and Antarctica) to assess the deeper impact of accessibility and available information on environmental care and risk perceptions.

4.1 | Symbolic values shape care about remote environments

Our results show that symbolic values have a significant impact on the environmental care attributed to the deep sea, and the same applies to the other remote environments. These values further mediate the perceptions of societal and environmental risk of mining. While the role of symbolic values as determinants of environmental care has not been evaluated, affective responses to environmental risks have been shown to drive risk perceptions (Böhm, 2003; Grasmück & Scholz, 2005). Here we also find a link between affective response (measured through symbolic values) and perceived risk, and greater environmental care implying a stronger positive affective response. Even for the Moon, for which we found the level of care to be lowest, environmental care is still linked to the perceived level of risk and the affective responses an environment invokes. However, while DSM was perceived riskier than mining in the other remote environments, people care less about the negative impacts on the deep-sea environment.

Antarctica and remote terrestrial environments were attributed more positive symbolic values than the deep sea. Nevertheless, the deep sea was considered the most exciting of the four environments. The unfamiliarity of the deep sea seems to result in what could be considered two opposing affective responses: the deep ocean is both exciting and mystical, while also being scary and slightly repelling. The latter, more negative connotations may explain the lower level of environmental care for deep sea compared to the other environments.

People viewed Antarctica as more beautiful and important than the deep sea, and cared more for its environment. While beauty is in the eye of the beholder, our results suggest that aesthetic values can give insight on how much people care about an environment and thus shed light on other relational values. However, the intrinsic value attributed to the deep sea was not significantly different from Antarctica, meaning that whether people find an environment important in its own right will not determine if they will care about it. In this respect, measuring only the intrinsic or existence value of an environment is not sufficient in capturing the factors contributing to environmental care, which the combination of symbolic values has allowed (Kagan, 1998).

4.2 | The link between knowledge and environmental care

Compared to the deep sea, Antarctica has gained quite a lot of research attention focussed on the aesthetic and wilderness value

of the continent (Jarvis et al., 2018; Neufeld et al., 2014; Shabudin et al., 2016; Summerson & Bishop, 2011, 2012). Antarctica is now also more accessible than before, as evidenced by increasing tourism (IAATO, 2018). However, the physical remoteness of an environment does not directly translate to its *perceived* remoteness (Barr & Kliskey, 2014), and different cultures have diverse ways of connecting with the ocean (Childs, 2019a; Šunde, 2008). The remoteness and emptiness of the deep sea have been used to legitimise DSM operations, by claiming that operations 'have no human impact' (Childs, 2019b). This perspective is strongly rooted in a western tradition while disregarding indigenous voices and the bond that, for instance, Pacific Islands' Ocean Nations have with the sea (Childs, 2019a; Hau'Ofa, 1994). In our study, we find that the remoteness and emptiness cannot support the view that operations will not have an impact on the intrinsic values (Zanoli et al., 2015) and the symbolic connections people have with these environments.

In contrast to the saying that we know more about the Moon than the depths of our oceans (e.g. Copley, 2014), we found that people know as little about the deep sea as the Moon. While the commonly held perception of the deep sea as a vast desert was transformed by scientific findings of its high biodiversity already decades ago (Roberts & Hirshfield, 2004; Van Dover, 2000), public literacy of the ocean and the deep sea seems to have not yet caught up to research findings (Ankamah-Yeboah et al., 2020; Fletcher et al., 2009; Guest et al., 2015).

Although knowledge has been shown to influence risk perceptions, with higher self-assessed knowledge linked with lower risk judgements (Grasmück & Scholz, 2005), we found self-assessed knowledge to be disconnected from risk perceptions. Similarly, knowledge of the environment was not connected to people's stated care. While knowledge of an environment can have an indirect effect on care, and care can transform knowledge into pro-environmental behaviour (Carmi et al., 2015), current research on environmental relations refutes the importance of knowledge in accounting for environmental awareness and behaviour (Jaspal et al., 2014; Kollmuss & Agyeman, 2002). We may thus know equally little about the deep sea as the Moon, but knowledge in itself does not mediate whether we care about it.

4.3 | Governance of unfamiliar environments

Despite respondents' low knowledge of human activities in the deep sea, DSM was considered more likely to occur in the near future than mining in Antarctica or on the Moon. Can the high proportion of respondents expecting exploitation of the deep sea be due to fast expansion of maritime activities (Jouffray et al., 2020), or are people simply used to activities in the ocean happening without being aware of them? While DSM initiatives in national waters have received media attention in their respective settings (e.g. Japan times, 2017), mining activities on the seabed beyond national jurisdiction, legally denoted as the 'Area', remain less discussed. From December 2020, 30 exploration contracts have been granted by the UN body responsible for regulating mining activities (the International Seabed Authority [ISA]) in the 'Area', with contractors waiting for the Exploitation Regulations (Mining Code) to come into place before mining can commence. The transparency of the ISA operations has been deemed insufficient by many stakeholders (Ardron, 2018), as commission meetings, data and information remain inaccessible to the public.

Consequently, DSM has not been widely discussed beyond industrial and technical circles, or within local settings (Waiti & Lorrenij, 2018). Debates about DSM are held within a relatively small group of activists and other parties, focussing on the technological advances of the industry, legislative issues or ocean conservation (DSM Observer, 2020). Despite the animated discussion and increasing effort to increase public awareness within these groups, broader consideration is hindered by the remoteness of the principal actors and the inaccessibility of information (Ardron, 2018). Although a larger social movement has not yet emerged as a result of low awareness of DSM activities, it is necessary to reflect on the legitimacy of operations and gaining social licence when dealing with global commons in remote locations.

4.4 | Societal engagement in deep-sea governance and social licence

The extent of the deep sea introduces challenges in determining from whom the social license for DSM should be obtained. Public discussions on the acceptability of mining are likely to be impeded by opposing views on the threats posed by mining activities and the potentially inequitably shared benefits (Filer & Gabriel, 2018). Currently, the consideration of social license by offshore industries is still limited, and the governance of ocean resources needs broader engagement with societal and political questions (Voyer & van Leeuwen, 2019). As deep-sea minerals in the 'Area' are considered common heritage of [hu]mankind (Article 136, UNCLOS, 1982), the general public is already acknowledged as an important stakeholder group for DSM (Clark et al., 2019; Durden et al., 2018; Levin et al., 2020). However, social licensing and impact assessment alone do not ensure just and sustainable DMS operations (Filer & Gabriel, 2018), nor should they be used only as tools to study the perceptions of mining (Carver et al., 2020). Examining public values and emotions towards the deep-sea environment, and ensuring a licence to engage (Uffman-Kirsch et al., 2020), will thus be important for understanding potentially divergent perceptions between stakeholder groups in the context of DSM to ensure legitimacy of offshore activities and account for indigenous and local knowledge and views of the deep sea (Ruckstuhl et al., 2014).

Given the difficult access to the deep sea, current governance of the deep sea space is viewed through mostly technocratic narratives (Reid, 2020). In turn, emotions in public and activist debates are often dismissed as irrelevant in contrast to the environmental and economic risks in environmental conflicts (González-Hidalgo &

Zografos, 2020). However, decision-making that disregards people's values risks creating feelings of powerlessness and disappointment, potentially resulting in conflicts and poor outcomes for both the environment and the society (Sultana, 2015; Wolsink, 2010).

Deep-sea environments evoke different emotional responses compared to other environments which may mean they should be treated differently in terms of conservation, management and governance. While deep-sea environments are not attributed to the same symbolic value as the more charismatic Antarctica, this does not mean that social license would be granted automatically. As emotions and values towards activities that have the potential to cause environmental harm are likely to impact the magnitude of social resistance (Ruiz et al., 2018), public attitudes towards deep-sea activities may be different. However, even if the public outcry would take a different form, it is unlikely that DSM activities could proceed without considering public concerns.

4.5 | Environmental stewardship of the deep sea

Studies in terrestrial realm have demonstrated a positive association between people's attachment to a particular environment and stewardship (Chapin III & Knapp, 2015; Stedman, 2003). Emotional affinity combined with values encourages nature-protective behaviour (Kals et al., 1999) and motivates conservation actions (DiEnno & Thompson, 2013; Jones et al., 2016). Deep-sea literacy has recently been approached through experiential practices, by enabling people to visit the deep sea using virtual reality (Salazar et al., 2019). Rather than trying to apply the same principles to the deep sea as other environments, nurturing the positive symbolic values such as mysticism and excitement could be more rewarding to encourage deep-sea stewardship. To support transparency in developing a sustainable Blue Economy (Bennett et al., 2019; Mengerink et al., 2014), it is important to both increase public awareness of deep-sea environments and human activities there, and to acknowledge the role of emotions in driving people's care towards developments in the deep sea. Full consideration of people's care for the deep sea involves a broader appreciation of the diverse human relationships with the ocean (Allison et al., 2020). Symbolic values and the associated affective responses offer powerful means to understand how people relate to different remote environments, and the diversity of these values should be evaluated further.

5 | CONCLUSIONS

How much do you care about environments that are far away and you do not know much about? In this study, we show that symbolic values are central in predicting environmental care and risk perceptions of mining activities in the deep sea. People care less about deep sea than other remote environments, which we find connected to the different emotions and meanings deep-sea environments evoke compared to other remote settings. We show that care is linked to the level of perceived risk and symbolic values attributed to an environment, and that people care more for environments for which they hold positive symbolic values. Using other remote environments as sentinels for the deep sea enabled us to validate the patterns, confirming that these are not concepts unique to deep-sea environments. While previous approaches on environmental values posit that values are informed by knowledge of an environment or based on relational aspects, we show that valuing and caring about unfamiliar environments rather draws on the emotions and moods associated with the environment. Our results thus show that accounting for the underlying affective responses towards the environment when evaluating risks of human activities in remote places is fundamental. Importantly, decision-making that disregards public values of the deep sea, the basic building blocks of social licence, and the opportunity for the public to engage in the decision process, runs the risk of creating conflict and poor environmental and societal outcomes. Encouragement to grow stronger connection and greater awareness of the deep sea to enhance feeling of care and nurture deep-sea stewardship will be crucial for equitable and sustainable ocean governance.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS' CONTRIBUTIONS

L.K. and I.v.P. designed the study; L.K. coordinated the study, analysed the data and produced the figures; L.K. and I.v.P. interpreted the results and wrote the manuscript jointly.

DATA AVAILABILITY STATEMENT

Data are freely available from Zenodo http://doi.org/10.5281/zenodo.4746177 (Kaikkonen & van Putten, 2021).

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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