



# Ten Thousand Voices on Marine Climate Change in Europe: Different Perceptions among Demographic Groups and Nationalities

Paul J. Buckley<sup>1\*</sup>, John K. Pinnegar<sup>1,2</sup>, Suzanne J. Painting<sup>1</sup>, Geraldine Terry<sup>2</sup>, Jason Chilvers<sup>2</sup>, Irene Lorenzoni<sup>2</sup>, Stefan Gelcich<sup>3</sup> and Carlos M. Duarte<sup>4</sup>

<sup>1</sup> Centre for Environment, Fisheries and Aquaculture Science, Lowestoft, United Kingdom, <sup>2</sup> School of Environmental Sciences, University of East Anglia, Norwich, United Kingdom, <sup>3</sup> Laboratorio Internacional en Cambio Global and Centre of Applied Ecology and Sustainability, Departamento de Ecología, Pontificia Universidad Católica de Chile, Santiago, Chile, <sup>4</sup> Red Sea Ecology, Biological and Environmental Science and Engineering Division, King Abdullah University of Science and Technology, Thuwal, Saudi Arabia

## OPEN ACCESS

### Edited by:

Philip Boyd,  
University of Tasmania, Australia

### Reviewed by:

Joanna Carey,  
Marine Biological Laboratory,  
United States  
Emily Rinvest,  
Virginia Institute of Marine Science,  
United States

### \*Correspondence:

Paul J. Buckley  
paul.buckley@cefas.co.uk

### Specialty section:

This article was submitted to  
*Global Change and the Future Ocean*,  
a section of the journal  
*Frontiers in Marine Science*

**Received:** 01 November 2016

**Accepted:** 15 June 2017

**Published:** 11 July 2017

### Citation:

Buckley PJ, Pinnegar JK, Painting SJ,  
Terry G, Chilvers J, Lorenzoni I,  
Gelcich S and Duarte CM (2017) Ten  
Thousand Voices on Marine Climate  
Change in Europe: Different  
Perceptions among Demographic  
Groups and Nationalities.  
*Front. Mar. Sci.* 4:206.  
doi: 10.3389/fmars.2017.00206

Over the past few decades, substantial funding has been directed toward improving scientific understanding and management of impacts of climate change in the marine environment. Following concerns that the key messages from these studies were not reaching the public, a comprehensive opinion poll of 10,000 European citizens in 10 countries was conducted to establish levels of awareness, concern, and trust among different demographic groups (by age, gender, proximity to the coast) and nationalities. Citizens exhibited varying levels of self-declared “informedness” and concern. Citizens from Germany, Italy and Spain claimed to be the most informed on marine climate change issues; those from Czech Republic, Netherlands and Estonia claimed to be least informed. Respondents were least aware of ocean acidification and most aware of melting sea ice, pollution and overfishing. Citizens of Italy suggested that they were generally most concerned about marine climate change issues. Respondents from coastal areas claimed to be both more informed and more concerned than those living inland, as did females and older age groups (54–64 years). European citizens obtain information about climate change in the seas and ocean from different sources, particularly television and the internet. Trust in the various media sources varies among countries and demographic groups. Television is trusted most in Estonia, Germany and Ireland and least in France. The internet is trusted most in Italy, Czech Republic and Estonia, but least in France and the United Kingdom. 18–24 year olds are the biggest users of the internet, but trust this source less than older age groups. Academic scientists or those working for environmental NGOs are trusted more than scientists working for government or industry. Citizens from France are more trusting of industry than any other country polled. In terms of policy actions, most respondents highlighted mitigation measures as opposed to local-scale adaptation. Younger participants prioritized actions

associated with reducing carbon emissions, whereas older age groups prioritized improving coastal defenses. Successful adaptation to the impacts of climate change requires public engagement and support for policy decisions, and the use of different approaches to take account of differences among demographic groups and nationalities.

**Keywords:** polling, climate change, ocean, public perception, mitigation

## INTRODUCTION

There is a growing body of work on public perceptions of the impacts of climate change (see Brulle et al., 2012). However, very little has been done on public perceptions of marine environmental issues in general (Jefferson et al., 2014; Potts et al., 2016) or on the impacts of climate change on the marine environment specifically. Over the past few decades, substantial funding has been directed toward improving scientific understanding and management of impacts of climate change in the marine environment. However the extent to which this knowledge has ultimately reached the public is unclear, and this was an area of significant concern to those responsible for commissioning research on this topic (Heip et al., 2011). This paper describes the findings from the first in-depth study into public engagement with marine climate change issues in Europe, which was conducted to establish levels of awareness, concern and trust among different demographic groups (by age, gender, proximity to the coast) and nationalities. The scale of this study, based around a public opinion poll of over 10,000 European citizens across 10 countries, provides a unique opportunity to quantitatively explore attitudes and awareness, and to place these views in the wider context of debates about science communication, sources of trust, and “ocean literacy,” and how best to target communications among different countries and demographic groups.

Ocean literacy is an issue that has received increased attention in recent years (e.g., Steel et al., 2005; Potts et al., 2016). The term ocean literacy has been broadly described as “understanding the oceans influence on you and your influence on the ocean” (Cava et al., 2005). Enhancing public awareness and knowledge, whether through media campaigns or interventions in the education system, has been viewed as essential to increase public support for ocean restoration projects and to achieve sustainable management of maritime environments in the longer-term. Recent studies (e.g., Gelcich et al., 2014; Jefferson et al., 2014) have highlighted the importance of improved understanding of impacts of human activities and environmental change on the marine environment, and including public perceptions in policy processes.

The impacts of climate change on the varied marine and coastal environments of Europe, ranging from sub-arctic to the sub-tropics and semi-enclosed basins to open-ocean are predicted to be significant. Some countries are likely to be much more vulnerable to future climate change and sea level rise than others (IPCC, 2014a,b). Public perceptions of climate change are known to differ between nations and have fluctuated over time (Capstick et al., 2015). In Europe, climate change is a major concern (Adelle and Withana, 2008). During the last

decade, a great deal of news media attention has focused on informing the public about scientific findings on anthropogenic global warming. Scientists, journalists and broadcasters have made use of television, feature films, newspaper articles and the internet, to get their message out (Malka et al., 2009), and inform public opinion. Trust in these various media outlets also varies markedly, depending on a wide range of different factors such as age, gender, political leanings, and nationality. It is useful to understand which media the public trust, in order to get communicate messages out effectively, targeting the most trusted and used media. A comprehensive body of research has now built up, offering advice on communication strategies for climate change science (e.g., Moser and Dilling, 2011; Patt and Weber, 2014). Worldwide, educational attainment appears to be the single strongest predictor of climate change awareness (Lee et al., 2015), although national, cultural and geographic factors also play an important role in shaping individual-level perceptions.

It is intuitive to assume that concern about climate change should be preceded by knowledge about its effects (Shi et al., 2016). However, several studies suggest that knowledge about climate change has only a limited effect on shaping concern about climate change issues. For example, Malka et al. (2009) found that in the United States, among people who trust scientists to provide reliable information about the environment, increased knowledge was associated with increased concern. However, among people who are skeptical about scientists, more knowledge was generally not associated with greater concern. Similarly, Kahan et al. (2012) found that members of the public with the highest degrees of scientific literacy and technical reasoning capacity were not necessarily the most concerned about climate change.

We conducted the first in-depth study into public engagement with impacts of climate change on the marine environment in Europe. The scale of this study, based on a public opinion poll of over 10,000 European citizens across 10 countries, provides a unique opportunity to quantitatively explore attitudes and awareness, and to place these views in the context of debates about science communication, sources of trust, and “ocean literacy.”

In two previous papers based on this polling survey (Chilvers et al., 2014; Gelcich et al., 2014) results by country were not described. Gelcich et al. (2014) focused on public awareness and concern at the wider European level regarding anthropogenic impacts in the marine environment, levels of trust in different information sources, and priorities for policy and funding. Key findings suggested that the level of concern regarding impacts in the marine environment was closely associated with the

level of “informedness,” and that pollution and overfishing were considered by the public to have higher priority for policy development. The level of trust varied greatly among different information sources and was highest for academics and scholarly publications but lower for government or industry scientists.

Chilvers et al. (2014) focused on the polling results for the United Kingdom (where 1,001 responses were received). Impacts of climate change on the marine environment were not the most immediate or significant issues for most UK respondents. Public understanding of marine climate impacts was shaped mainly by personal experience, the visibility and proximity of impacts, sense of personal risk and moral or equity-based arguments. Poll participants prioritized climate change mitigation measures over adaptation, even if they lived in vulnerable low-lying coastal areas.

The aim of the work carried out here was to test whether attitudes to impacts of climate change on the marine environment differed by country, age and gender. Poll results were used to identify concerns and implications of climate change impacts such as melting sea ice, coastal flooding, sea level rise and changes in the frequency of extreme weather events. Poll results were also used to determine levels of awareness, concern, trust and perceptions of action required.

## METHODOLOGY

### Polling Approach

An international market research organization (TNS Opinion) was selected to undertake the poll, based on their previous experience of pan-European polling through the annual Eurobarometer survey (e.g., CEC, 2008; European Commission, 2009). The polling organization made use of established national panels of citizens. The poll was designed as an online questionnaire, which could be completed in a short period of time (20 min). Participants were given a 19-day period (5-24 January 2011) to complete the questionnaire.

Panels of more than 1,000 respondents in 10 countries (Figure 1) provided representative data to examine local, national and pan-European opinions in accordance with key socio-demographic indices such as gender and age. Where appropriate, the survey design also included a robust coastal over-sample of 150 people, based on a list of coastal regions within each country, allowing comparisons on marine issues to be made between those living near the coast and those living inland. With regards to the total sample for each country, the coastal over-sample was then weighted to ensure that the total sample was nationally representative (i.e., not over-inflated with coastal respondents). One land-locked country (Czech Republic) was included to provide an example of how opinions in countries with a coastline differed from opinions in a land-locked country.

The other nine countries were carefully selected based on their geographic location (i.e., proximity to different regional seas of Europe, from the Arctic through to the Mediterranean), total population numbers, length of coastline and perceived vulnerability to climate change (e.g., exposure to sea level rise). Political differences were also considered; hence the inclusion



**FIGURE 1** | The 10 countries surveyed in the CLAMER poll were Norway; Netherlands; United Kingdom; Germany; Estonia; France; Ireland; Czech Republic; Spain and Italy.

of former eastern bloc countries (Estonia and Czech Republic), original EU-17 countries (who acceded prior to 2004) and a non-EU member state (Norway, also included to capture an “Arctic” sea coast).

The sample was randomly stratified in each country according to age, sex, and region (Table 1). Stratification by age group (18–64 age bracket) was performed. A sample of 1,000 individuals per country is statistically accurate to 3.1% ( $\pm$ ) at a 95% confidence level and is believed to facilitate a good standard of analysis within each country. There is a small inherent bias in using an online survey methodology relating to internet accessibility in the population. However, recent demographic statistics indicate that on average, in Europe, 78% of households now have internet access at home (see Potts et al., 2016).

A very large and wide-ranging dataset was compiled. It was therefore possible to test for significant statistical differences between populations (such as gender/age), using standard statistical approaches used in the market research industry (see Agresti, 2002; Brechin, 2003; Gelman and Hill, 2006; Gelcich et al., 2014). For this analysis, given the large sample size and the known variance, a z-test was applied to column proportions to identify significant differences at the 5% level (without Bonferroni method adjustment). Statistical differences were examined between countries, as well as by age, gender, proximity to the sea and regional sea experienced most at the total sample level. Throughout this paper, we use the term “significantly different” to describe instances where there was a statistical difference between groups at the 95% confidence level (e.g., 65% of women “trusted” what they learnt about impacts of climate change on the marine environment from television compared to 54% of men, which is statistically higher at the 95% confidence level, taking account of the size of the sample population).

**TABLE 1** | Age and gender split of the interviewees in the nationally representative samples for each country surveyed.

	Total	Gender		Age					
		Male (%)	Female (%)	18–24 (%)	25–34 (%)	35–44 (%)	45–54 (%)	55–64 (%)	65+ (%)
<b>Country</b>	10,106	48	52	10	16	19	18	15	22
Czech Republic	1,032	48	52	12	18	19	16	17	18
Norway	1,006	50	50	14	17	18	17	15	19
Estonia	1,003	45	55	14	18	16	17	14	21
UK	1,001	48	52	11	19	19	16	14	21
Netherlands	1,003	49	51	11	16	19	18	17	19
Germany	1,006	48	52	10	13	20	19	14	24
France	1,007	48	52	11	16	17	18	15	22
Italy	1,009	48	52	9	16	20	17	15	23
Spain	1,026	49	51	10	20	20	18	13	19
Ireland	1,013	50	50	15	21	21	16	13	14

## Questionnaire Development

The initial questionnaire development stage was informed by a review of existing literature on public perception studies regarding climate change and marine environments (Terry and Chilvers, 2011) as well as expert guidance from the polling agency. Lists of marine climate change research themes to include, as well as technical questions on rates and magnitudes of change, were informed by the “Synthesis of European Research on the Effects of Climate Change on Marine Environments” produced during the EU FP7 project CLAMER (Heip et al., 2011).

The questionnaire was split into five distinct sections. The first section included general views on climate change as a major global issue, as well as two open-ended questions on what comes to mind when thinking about *marine environmental issues* and then specifically *climate change issues* at the coastline or in the sea. For a multi-country survey of this size, it was unusual to include open ended questions given the effort required to translate and code each response (in 10 European languages). Each of the two open ended questions yielded over 30,000 individual responses across the total of over 10,000 respondents, providing unique insights into the opinions of European citizens on the marine environment and impacts of climate change on the marine environment issues specifically. Open ended questions are valuable in surveys such as this as they allow us to gain an understanding of how an issue is perceived without placing any constraints on the response. For this survey, it also enabled us to place concerns about climate change in the context of wider marine environmental issues (see our previous paper, Gelcich et al., 2014). To visualize the most common themes emerging from these open questions, word clouds were created for each country, using the online tool Wordle (2017), by inputting the individual responses into software that emphasized the most common responses (such as sea level rise) according to the number of times that they were mentioned (for example, see Figures 3, 4).

The second section focused on awareness and concern on a broad range of prompted marine environmental issues, including some specifically related to climate change. The third section

was on marine climate change “literacy” to understand if the public have a good awareness of scale and magnitude of key marine climate change issues. The fourth section was on sources of information and trust in organizations or individuals, and the final section was on policy responses and priorities.

An invitation to participate was sent to all participants. The survey topic was not given initially, to avoid over-representation of people with a particular interest in marine or climate change issues and therefore to avoid any bias in the results. Polling was conducted in accordance with the UK Data Protection Act and the MRS Code of Conduct. The final version of the questionnaire is provided in the Supplementary Material (Supplementary Annex S1).

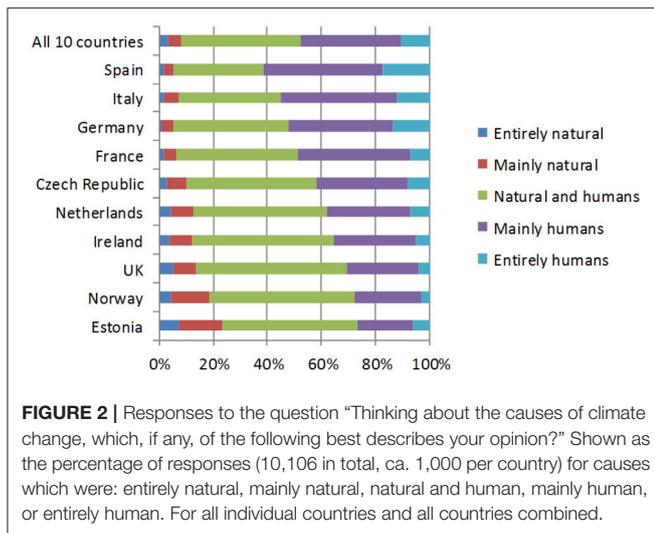
## RESULTS

### General Perceptions of Major Global Risks and Climate Change

When asked about general perceptions of major global risks, 18% of all respondents said that climate change was the most serious problem facing the world. Concerning the *causes* of climate change, almost half of all respondents (46%) believed that climate change is either “mainly” or “entirely” caused by human activity and 42% thought that climate change is caused “partly by natural processes and partly by human activity.” Only 8% thought climate change was either “mainly” or “entirely” caused by natural processes (with a further 1% saying climate change did not exist and 2% saying “don’t know”). At the country level there were marked differences in opinion, with over 60% of Spanish respondents saying that climate change is either mainly or entirely caused by humans, compared to only 26% of Estonians (see Figure 2).

### Open Ended Questions

The 10-country survey initially asked people to identify, in their own words, three important environmental issues relating to the coastline or the sea. The answers revealed that for the public overall in these 10 European countries, pollution is by far the most important environmental issue in relation to the coastline



or the sea. The words “climate change” were only explicitly mentioned in four percent of responses. Several related impacts were mentioned as “important marine environmental matters,” including coastal erosion, sea level rise, melting ice caps, sea temperature rise and flooding, although not framed as “climate change” explicitly. The framing of climate change issues as part of wider marine environmental issues is discussed in more detail in Gelcich et al. (2014).

After asking respondents to name important coastal and marine environmental issues in general, the survey then asked them to name three marine or coastal impacts of climate change specifically, again in their own words. In answer to this question, sea level rise was mentioned most often, accounting for almost 14% of responses. Responses worded as “nothing” or “don’t know” when combined came a very close second. This indicates that a large proportion of the public may have struggled to identify more than one or two marine or coastal climate change impacts.

Whilst sea level rise was a common theme mentioned by participants across all countries (results not shown here), it is interesting to note that for the UK and Ireland, responses were clearly focused around a few key issues (see **Figure 3**). Coastal erosion came out as the top response for both countries, accounting for almost 20% of responses. This compares to figures of 10% or lower for coastal erosion in all other countries, where responses were typically spread more evenly across a wide range of different topics, see for example the responses from Italian respondents (**Figure 4**). A 2013 national survey of 1,848 UK residents into climate change beliefs and perceptions of weather-related changes in the United Kingdom (Taylor et al., 2014), highlighted coastal erosion as one of the key weather-related events that the public believe has become more frequent during their lifetime, scoring higher than heat and drought related events.

## Awareness and Concern

Respondents were exposed to a predetermined list of key marine environmental issues, both climate and non-climate related. They

were asked how “informed,” and then “concerned,” they felt about these topics. **Figure 5** shows the top 2 box percentage scores for informed and concerned, using a 5 point likert-scale, across all of the countries surveyed.

For “concern,” “marine pollution” came out as the number one issue, across all 10 countries. This strongly echoed the “unprompted” responses provided earlier in the questionnaire. A number of climate change issues scored highly for concern (70% or more top 2 box), namely melting sea-ice, coastal flooding, sea level rise and changes in the frequency or magnitude of extreme weather events (see **Figure 5**).

At the individual country level, German, Italian and Spanish respondents were the most highly informed on the greatest number of topics, whilst Dutch, Czech and Estonian respondents were the least informed (**Figure 6**). Czech, Dutch and Estonian respondents also came out as being amongst the least concerned across the 15 issues covered, along with Norwegians, whereas Italians were the most highly concerned on the greatest number of issues (10 of 15 issues), with Irish, Spanish and German citizens also showing relatively high levels of concern when compared to other countries.

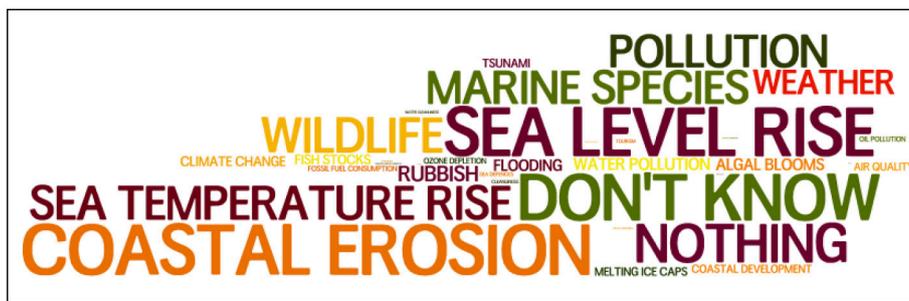
For concern, it is interesting to note that whilst coastal flooding and sea level rise were the joint second highest concern for the Dutch (after pollution), the level of concern on these issues was significantly lower than the 10 country average. This is despite the widely-held perception (for example among the CLAMER scientists involved) that citizens of the Netherlands would be most concerned by sea level rise and coastal flooding, due to the country’s low-lying geography.

Respondents living in coastal areas claimed to be both more informed and more concerned than those living inland, for all 15 issues. In particular, coastal respondents were more informed about coastal erosion (41% top 2 box for “informed” in the coastal sample vs. 29% non-coastal) and jellyfish blooms (30 vs. 20% respectively). For “concern,” differences were particularly marked for coastal erosion (71% “concerned” vs. 59%), as well as ocean current changes (61 vs. 52%), marine invasives (61 vs. 50%) and jellyfish blooms (58 vs. 47%). All of these differences were statistically significant at the 95% confidence level. The coastal sample expressed significantly higher levels of concern across all issues. Females expressed statistically higher levels of concern than men for all issues except overfishing, and in general older people expressed higher levels of concern than the young (e.g., for all 15 issues, 55–64 year olds were significantly more concerned than 18–24 year olds, **Table 2**).

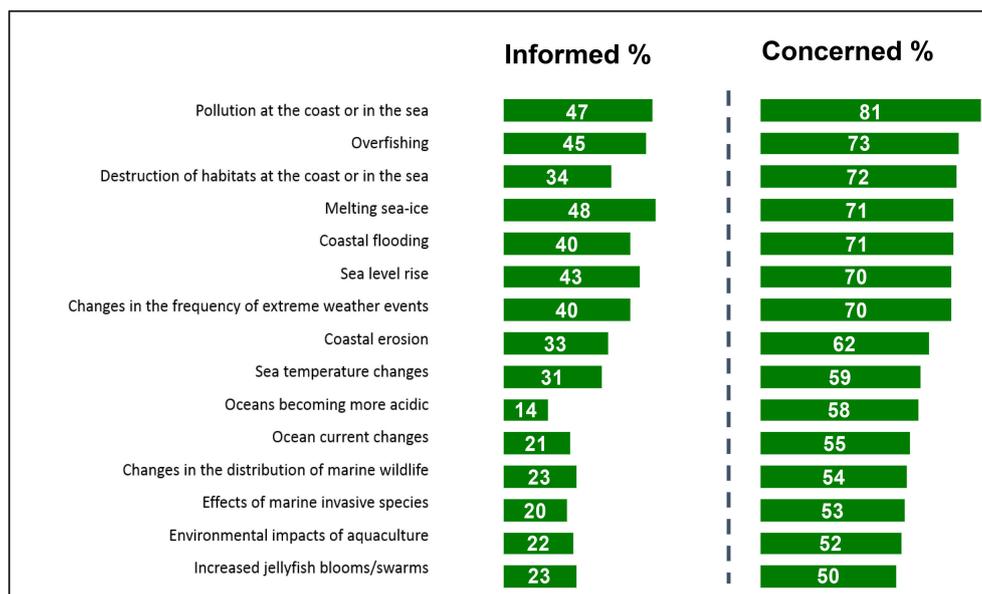
People living near to the Baltic and Mediterranean or visiting these regions most often, expressed greater levels of concern for sea temperature change compared to those associated with other European seas. People visiting the Mediterranean were more concerned about marine invasive species and jellyfish blooms compared to those based in other regions. Habitat destruction stood out as a concern for those visiting the Baltic. Surprisingly, melting sea-ice was seen as much less of a concern amongst people who regularly interact with the Arctic Ocean compared to those that associated with other seas, although it should be noted



**FIGURE 3** | Most frequent responses in the UK to the question “Which three things, if any, come to mind when you think about the impacts climate change on the coastline or the sea” (based on 3,003 total responses from 1001 respondents).



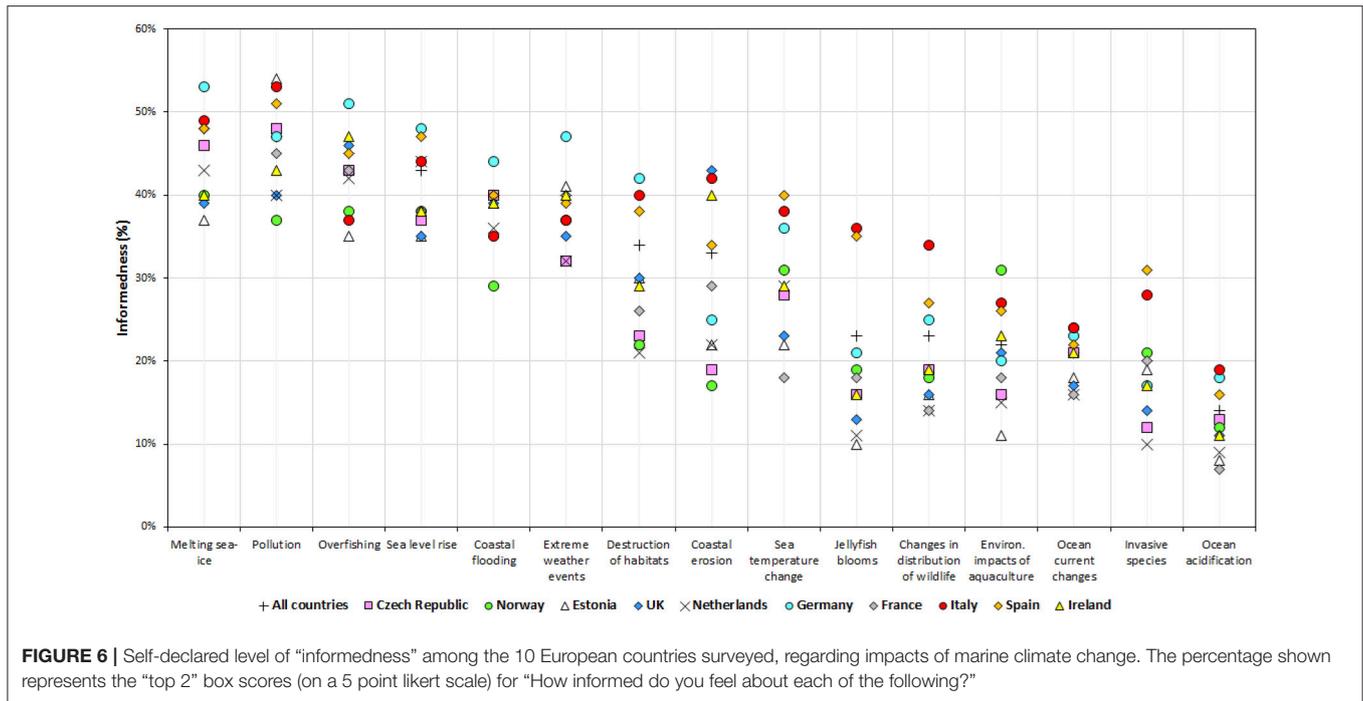
**FIGURE 4** | Most frequent responses in Italy to the question “Which three things, if any, come to mind when you think about the impacts of climate change on the coastline or the sea” (based on 3,027 total responses from 1009 respondents).



**FIGURE 5** | The top 2 box percentage scores (on a 5 point likert scale) for “How informed do you feel about each of the following? ‘/’... and now please indicate to what extent do you feel concerned about each of the following?” Sample = all 10 countries combined; N = 10,106 respondents.

that the overall base-size was relatively low for the sub-sample visiting the Arctic, with only 81 respondents, almost exclusively in Norway.

Finally, informed-ness and concern on all issues was generally higher amongst people who interact regularly with the sea, especially for those whose work is related to the coast or the sea,



**FIGURE 6 |** Self-declared level of “informedness” among the 10 European countries surveyed, regarding impacts of marine climate change. The percentage shown represents the “top 2” box scores (on a 5 point likert scale) for “How informed do you feel about each of the following?”

**TABLE 2 |** Self-declared level of “informedness” among the different demographic groups surveyed, regarding impacts of marine climate change.

	Gender			Age					
	Total (%)	Male (%)	Female (%)	18–24 (%)	25–34 (%)	35–44 (%)	45–54 (%)	55–64 (%)	65+ (%)
Melting sea-ice	48	50	45	51	43	44	46	50	53
Pollution	47	48	46	47	43	42	45	51	53
Overfishing	45	49	41	38	41	40	43	49	53
Sea level rise	43	45	40	45	41	39	40	44	47
Coastal flooding	40	41	39	39	35	36	38	45	44
Extreme weather events	40	42	37	39	36	37	40	41	43
Destruction of marine habitats	34	35	34	34	30	30	32	38	41
Coastal erosion	33	35	30	36	27	29	31	39	41
Sea temperature change	31	34	28	29	27	27	32	35	35
Jellyfish blooms	23	24	22	18	21	19	24	26	28
Distribution of marine wildlife	23	23	22	23	22	19	22	23	26
Impacts of aquaculture	22	23	21	21	20	17	23	25	24
Ocean current changes	21	23	18	18	19	18	21	22	24
Invasive species	20	22	19	17	18	20	21	21	23
Ocean acidification	14	16	13	15	13	12	13	16	16

The percentage shown represents the “top 2” box scores (on a 5 point likert scale) for “How informed do you feel about each of the following?”

compared to those who claimed not to interact with the sea at all, although only 5% of the total sample claimed not to interact with the sea at all.

### Awareness of Magnitude and Rates of Change

To help interpret whether understanding among the European public is consistent with current scientific knowledge, respondents were asked a series of questions relating to

two common *direct* measures of warming effects on the marine environment, namely sea temperature change and sea level rise. Broadly speaking, the estimates provided by the public accorded well with expert opinion.

For sea level rise over the next 100 years, 40% of respondents in this survey suggested that sea-level would rise by 10 cm to 1 m (from a choice of no rise; less than 10cm; 10cm to less than 1 m; 1 m to less than 5 m; 5 m to less than 10 and 10 m or more), with a further 27% saying the figure would be between 1 and

5 m. Given that the IPCC 5th assessment report (IPCC, 2013) indicates a likely increase of 26–82 cm by end of century and some studies suggest that increases in sea level of over a meter are possible by 2,100 (see for example Brown et al., 2013), it would seem reasonable, given the uncertainty surrounding sea level projections, that the estimates provided by two thirds of respondents matched well with expert opinion.

For sea temperature rise, the general consensus amongst the public was that sea temperature has risen by less than 2 degrees centigrade over the past century (70% of respondents). Over the coming century, the amount of change predicted by the public was generally higher, largely due to an increase in respondents saying change would be between 2 and 5° centigrade. Both of these estimates for past and future sea temperature change accord well with general scientific consensus. For example, the CLAMER Synthesis Report (Heip et al., 2011) states that “the current trend of warming is likely to continue with increases of 2°C and more over this time frame [next 100 years].” Differences in opinion between countries were quite marked, however. For example, only 32% of Estonians thought sea temperature rise would exceed 2°C in the next 100 years compared to 61% of Spaniards.

Respondents were then asked to consider *when* a range of key marine and coastal climate change impacts would become apparent (see **Figure 7**). The pooled European data showed that for all six of the issues, at least 50% of the public thought that impacts would become apparent in the next 20 years. When asked about “changes in the frequency of extreme weather events (e.g., storms)” over 50% of the respondents thought that impacts were *already* apparent, a view now supported by the UK Met Office following the exceptional windstorms and flooding experienced at the start of 2014 (Met office, 2014).

Respondents who were “concerned” about the impacts of climate change (see previous section) were more likely to say they could already see these impacts happening.

Despite broad-scale agreement across all countries that changes in the frequency of extreme events are either already apparent, or would become apparent in the next 20 years, for the other five issues, respondents from certain countries thought these impacts were a more immediate threat. For “major economic impacts from coastal flooding,” respondents from Ireland, Czech Republic and France, considered this as a more immediate threat than in other countries. Interestingly, The Netherlands stands out as the country that did not have this opinion, with only 21% of respondents saying “major economic impacts from coastal flooding” were already apparent. “Extensive loss of land to the sea,” was regarded as being an immediate threat to French respondents, and to a lesser extent Irish, Italian and UK respondents. Estonia and Norway stood out as the countries that believed that loss of land to the sea would not become apparent until much further in the future. “Ocean current changes leading to sudden/abrupt climate change in Europe” was again a more immediate concern according to Irish, as well as French and Italian respondents, with Norwegians least likely to say this was already happening. Complete melting of Arctic sea-ice in the summer was again seen by French respondents as a much more immediate issue than for any of the other countries polled.

Ocean acidification (OA) was seen as a more immediate threat in Germany, Italy, France and the Czech Republic. In the UK and Norway, almost 30% of respondents said they did not know when impacts from OA would become apparent (compared to the average of 18% for all countries combined). Given the lack of self-declared informed-ness on ocean acidification in earlier questions, it is perhaps surprising that the percentage of respondents not knowing when ocean acidification would start to affect sea life was not higher across the survey.

Looking at demographics, females were more likely than males to say that impacts were already apparent for all six issues and in general, the youngest (18–24) and oldest (65+) respondents were less likely to say that impacts were already apparent.

For those issues relating to coastal impacts, i.e., coastal flooding or extensive loss of land to the sea, a higher percentage of people living in coastal areas said that impacts were already apparent, when compared to those living inland. For the other four issues there was no significant difference between coastal and inland samples.

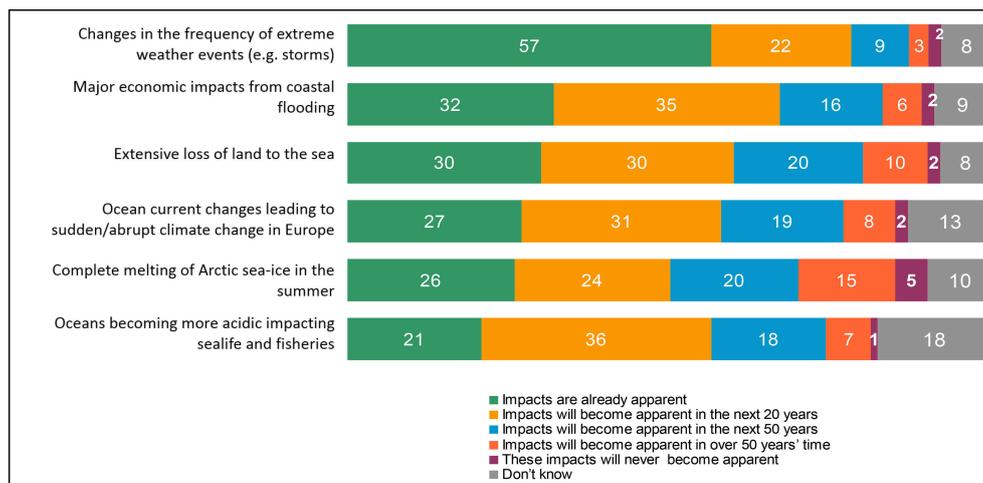
When considering differences in opinion by regional sea experienced most often, respondents visiting or living near to the North Atlantic and Mediterranean were most likely to think that climate change was already causing extensive loss of land to the sea, as well as major economic impacts from coastal flooding. The latter was also true of those visiting the Black Sea, although it should be noted that the base-size for people visiting the Black sea was relatively low (60 respondents). People visiting the Baltic were more likely to say that climate change was already causing changes in the frequency of extreme weather events. With regard to melting sea-ice, those citizens visiting the North Atlantic were most likely to say that climate change was already leading to the complete melting of Arctic sea-ice. For ocean acidification, those people visiting the Baltic, or the Black Sea thought this was already happening.

## Information Sources and Trust

A key area of interest is *how* European citizens obtain information about climate change impacts at the coast or in the sea and to what extent they *trust* different sources of information. The dominant information source across all countries was television and in general, there was a good degree of trust in television as a source of information.

Trust was particularly high in our survey for scientific publications, and a surprisingly large percentage of respondents (29%) claimed that they had heard about climate change impacts at the coastline or in the sea through this medium (**Figure 7**). This high percentage may be due to scientific publications being cited through other mediums and through articles in popular special interest magazines (e.g., New Scientist, Science and Vie, Scientific American, Spektrum der Wissenschaft).

The UK and The Netherlands both stood out as countries that, in general, claimed to receive the least information on marine climate change issues and also had the lowest levels of trust (**Figure 8**). Both these countries claimed to have low levels of use, and trust in, the internet and scientific publications as sources of information on impacts of climate change on the marine environment. It is interesting to note that respondents



**FIGURE 7** | Results to the multiple choice questions “When, if at all, do you think the following impacts of climate change on the coastline and seas of Europe will become apparent?” Sample = all 10 countries combined;  $N = 10,106$  respondents.

from the UK (as well as Ireland) claimed to obtain a relatively high percentage of their information on marine climate change issues from government reports (20% vs. an average of 11% for the results pooled across countries). The UK and Ireland have relatively well organized systems in place for reporting on marine climate change issues (most notably through the UK Marine Climate Change Impacts Partnership–MCCIP) as well as legislative requirements (under the UK Climate Change Act, 2008) to provide a Climate Change Risk Assessment (CCRA) every five years.

There were a number of other significant differences regarding trust in different information sources across the countries polled (**Figure 8**). For the most popular medium, television, Estonian, and to a lesser extent German and Irish respondents trusted this medium the most as a source of marine climate change information. French respondents trusted television the least amongst the countries polled. For the second most popular source of information, the internet, both its use as a source of information on marine climate change, and trust in it, was highest in the Czech republic (81% usage and 65% trust) and Estonia (74% usage and 62% trust). Although fewer people used the internet as a source of climate change information in Italy, trust was very high at 70%. Indeed, self-reported trust in all sources of information (except TV, radio and film) was relatively high in Italy compared to all other countries. The Europe-wide difference in trust according to different types of newspapers was stark, when considering broadsheet (67% trust and 10% distrust) vs. tabloid papers (23% trust and 43% distrust) providing information on marine climate change. UK, Norwegian, Italian and German citizens trusted tabloid newspapers more than was typical in other countries, whereas French, Czech, Estonian and Italian citizens trusted broadsheet newspapers more than was typical elsewhere.

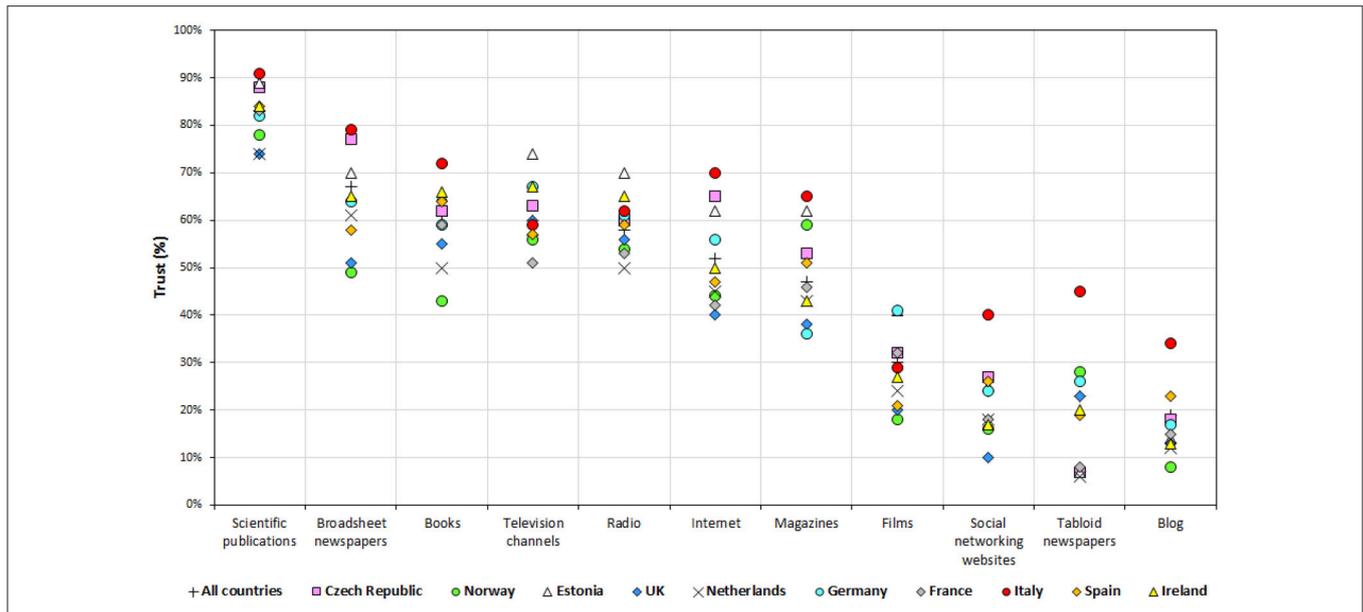
Looking at demographics, 18–24 year olds were the biggest users of the internet, films and social networking sites as

sources of information. There was a clear reduction in receiving information from friends and family with age, with 32% of 18–24 year olds getting information through friends and family compared to just 14% for the 65+ age group. With regard to trust, females were more trusting than males for all information sources, and in particular television (65 vs. 54% respectively). Trust also tended to increase with age.

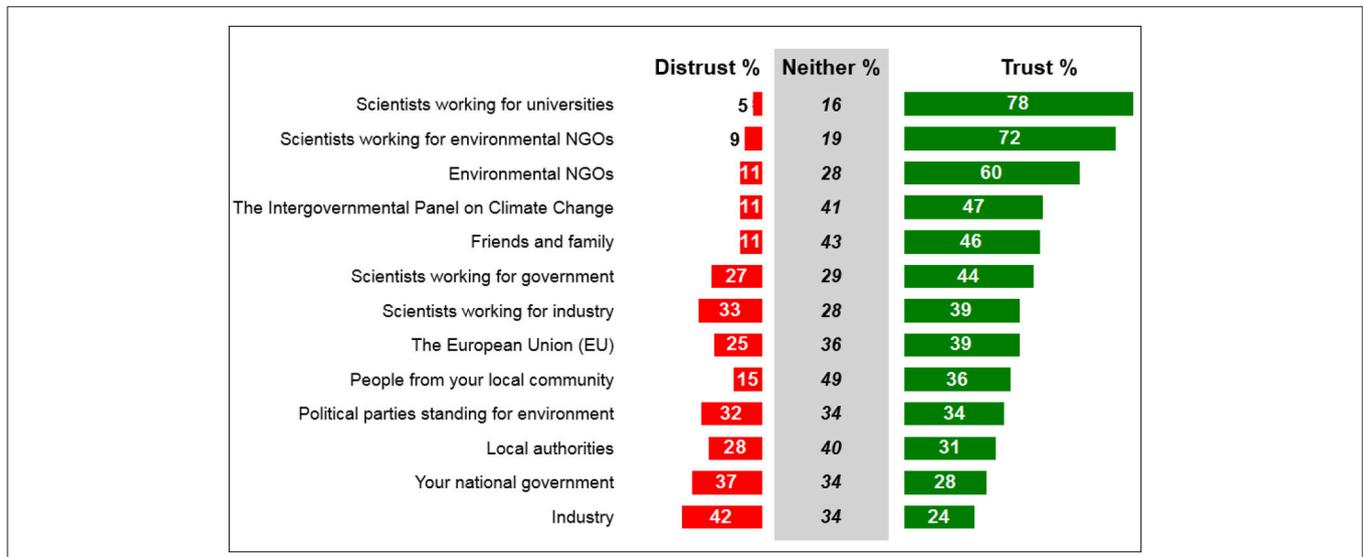
For most sources of information, trust was significantly greater amongst people living in coastal areas than for those living inland, and was lower amongst people most frequently visiting the North Sea, North Atlantic and Arctic. However, this may be an artifact, reflecting the fact that some of the least trusting national populations (UK, The Netherlands and Norway) lie in close proximity to these particular regional seas.

With regard to trust in *individuals and organizations*, scientists working in research institutes or for NGOs were clearly the most trusted groups, along with NGOs themselves (**Figure 9**). Industry, local and national government did not score highly, and when scientists were associated with either of these, trust was far lower than for “pure” academics or those linked to NGOs. Whilst the EU didn’t rank highly overall, it fared better than other political or governmental bodies.

Between countries, some marked differences in trust and distrust were apparent (**Figure 10**). For industry, distrust was as high as 61% in Germany but only 21% in France. This pattern of distrust extended to scientists in industry with 50% distrust in Germany compared to only 15% in France. Citizens of the Czech Republic and Ireland were most likely to distrust their national governments, whilst the Dutch and Norwegians were least likely to do so. Respondents from the UK and Germany were most likely to distrust the EU, in contrast—levels of distrust of the EU were lowest amongst Italian respondents (**Figure 10**).



**FIGURE 8 |** Self-declared “trust” in different media sources among the 10 European countries surveyed. “Trust” = respondents answering 4 or 5 on a five-point scale, where 5 = trust a lot and 1 = distrust a lot. “Neither” = respondents answering the mid-point (3) on the same five-point scale.



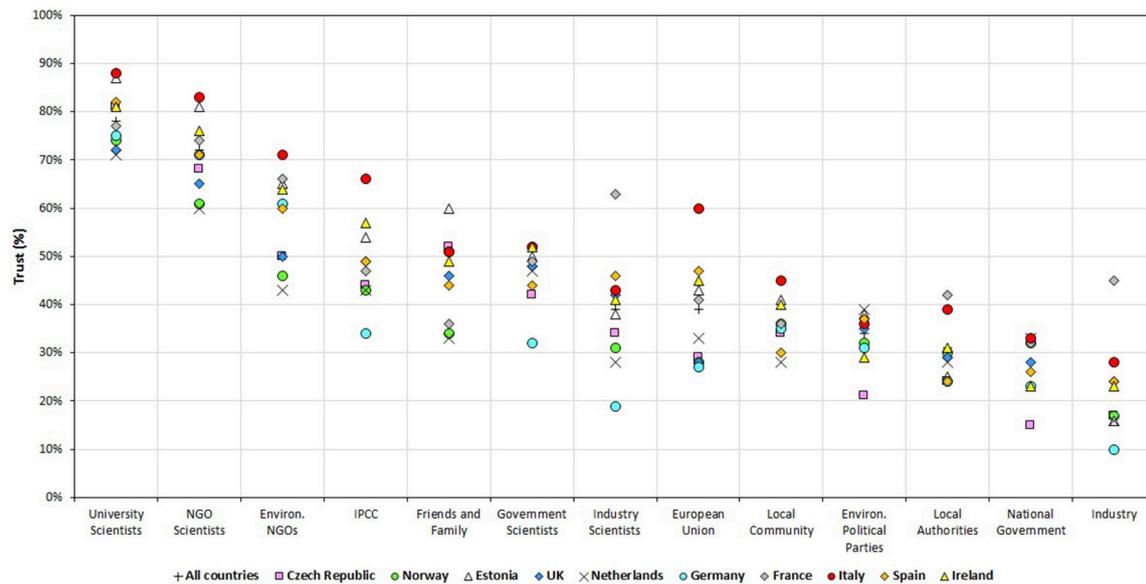
**FIGURE 9 |** Results from multiple choice questions “To what extent, if at all, do you trust\* each of the following individuals or organizations when providing information about climate change impacts on the coastline or the sea?” [Sample = all 10 countries combined; N = 10,106 respondents]. \* “Trust” = respondents answering 4 or 5 on a five-point scale, where 5 = trust a lot and 1 = distrust a lot. “Neither” = respondents answering the mid-point (3) on the same five-point scale.

### Policy Actions

In the final section of the survey, respondents were asked to think about a range of marine and climate change *policies*, and to highlight areas of scientific research that they considered most important for the EU or national governments to prioritize.

When asked about the top three priorities for EU marine and climate change policies, by far the most popular response from a pre-defined list was a tightening of controls on chemicals released into the sea. The most prominent climate

change issues were related to climate change mitigation (either limiting emissions through international agreements or actively removing CO<sub>2</sub> from the atmosphere), with research into the impacts of, and adaptation to, climate change at the coast or in the sea coming near the bottom of the list. These findings were also reflected in a participatory workshop that complimented this quantitative study, held in East Anglia in the UK. Study participants prioritized climate change mitigation measures over adaptation, even where they lived



**FIGURE 10 |** Self-declared levels of “trust” in different organizations and types of government, among the 10 European countries surveyed. “Trust” = respondents answering 4 or 5 on a five-point scale, where 5 = trust a lot and 1 = distrust a lot. “Neither” = respondents answering the mid-point (3) on the same five-point scale.

in high-risk areas at the coast (see Terry and Chilvers, 2011).

At the country level, tightening controls over chemicals was the top priority for all countries polled (57%). This was a particularly popular response for Estonia and the Czech Republic, where 71 and 69% of respondents respectively, included this in their top three priorities. Tightening controls over commercial activities in the sea also scored particularly highly in these two countries, with 58% of respondents listing this in their top three priorities in the Czech Republic and 57% in Estonia. Of the other three most popular responses, namely reducing fishing pressure, international commitments to cut greenhouse gas emissions tightening controls over commercial activities in the sea (37% each), reducing fishing scored highly everywhere except Italy. Agreeing on international commitments to cut climate change was a more popular choice in Italy (along with Spain) and was least popular in France. Improving coastal defenses featured highly in the UK (32%) and the Netherlands (28%) but scored only 9% in Norway and 10% in Spain. Increasing use of energy from low carbon sources was also relatively popular in the UK, as well as in France and Ireland but much less popular in the Czech Republic. Norway stood out as the country where researching climate change impacts at the coast or the sea found most favor with 25% of respondents including this in their top three priorities.

The youngest age group (18–24) tended to prioritize policies associated with reducing the amount of CO<sub>2</sub> in the atmosphere more than older age groups, whether through international agreements, developing low carbon energy sources or technologies to actively remove CO<sub>2</sub> from the atmosphere. Tightening controls over the chemicals into the sea, whilst still

the most popular response amongst 18–24 years, was prioritized much lower than for the oldest two age groups (48 vs. 61%). The oldest two groups were also more likely to say that improving coastal defenses was a priority compared to younger age groups.

There were a number of notable differences according to the sea with which respondents interacted with most. People visiting the Baltic Sea most often were more likely to prioritize “tightening controls over commercial activities in the sea” than people visiting other seas (except the Black Sea, but the base size for this sea was relatively low). Respondents visiting the North Sea were most often likely to choose “improving coastal defenses” as a priority.

## DISCUSSION

### Differences in Views and Awareness among Countries

Probably the most important finding of the polling study conducted here is that most concerns, regarding climate change in the seas and ocean, were common across all 10 countries examined, with marine pollution, but also melting sea-ice, coastal flooding, and sea level rise being highlighted as areas of particular interest and concern for most European citizens. Other authors (e.g., Reiner et al., 2006) have noted that despite sharp differences in government policy, the views of the respondents on energy and global warming were remarkably similar across countries, for example those in the US, in Sweden, Britain, and Japan. According to these authors (Reiner et al., 2006), Americans do exhibit some differences, placing lower priority on the environment and global warming, and with fewer believing

that “global warming has been established as a serious problem and immediate action is necessary,” but in Europe views on this topic are remarkably uniform (European Commission, 2009).

Whilst many studies have highlighted the strong correlation between how informed respondents perceive themselves to be and how concerned they are (e.g., Malka et al., 2009; Tobler et al., 2012; Shi et al., 2016), it is clear that other factors, such as how issues are framed, as well as personal values such as experience, emotions and empowerment are important (Malka et al., 2009; Jefferson et al., 2014). Nevertheless, in this study there was a strong correlation shown between self-declared informedness and concern (see Gelcich et al., 2014), albeit with a few exceptions, most notably for “oceans becoming more acidic” with only 14% of people saying they were “informed” about this issue (with a figure as low as 7% in France) but with 58% of people being “concerned” about it. Subsequent to the survey being conducted more in-depth polling work on ocean acidification was conducted in the United Kingdom by Capstick et al. (2016), and in the Alaska (Frisch et al., 2015). Both of these studies reiterated that there is little public awareness and understanding of ocean acidification compared to climate change in general.

Much has been written about the factors that shape public attitudes in different countries (e.g., Lorenzoni and Pigeon, 2006; Lee et al., 2015). Why are some nationalities more concerned about certain issues than others? Are some nationalities characteristically “more concerned” than others in international opinion polls? Levels of climate change awareness, knowledge, and support for mitigation or adaptation vary greatly across the world (Lee et al., 2015).

At a cross-cutting European level, repeated surveys commissioned by the European Community/the European Union have provided an indication of trends in concern with regard to environmental issues since 1992 (the “Eurobarometer” surveys). These surveys have highlighted consistent patterns and differences in the responses of European nationalities, for example the survey in 2002 (EORG, 2002) highlighted that the most worried countries (with regard to climate change) were southern European states such as Greece (63%) and Italy (49%), whilst the least worried were northern European nations such as The Netherlands (21% of very worried respondents), Ireland (25%) and the UK (26%) (Lorenzoni and Pigeon, 2006). Similar patterns were observed in our own polling study of European citizens, even though the polls were conducted 10 years apart.

Another poll in 2002 (see Lorenzoni and Pigeon, 2006) indicated that most Europeans were worried about future changes to the climate but again, there were more people worried (considering those who replied “very much” and “quite a lot”) in southern European countries (such as 86% in Italy, 85.4% in Greece and 83.8% in Portugal) compared to more northern ones (e.g., 49.1% in The Netherlands; 58.7% in Sweden and 61.2% in Ireland). The 2004 “Eurobarometer” survey (TNS Opinion and Social, 2005) of public opinions, included the 10 most recent Member States (MS) that joined the EU on 1st May 2004. Significant differences were evident between responses in the former EU-15 and the newer 10 MS. On average, climate change was the most mentioned environmental concern in the EU-15

(47%), whereas it was only mentioned by 34% of respondents in the newer 10 MS. In the present survey, we found very little difference in the responses of the newer EU member states examined (Czech Republic, Estonia) compared to the former EU-15 member states that were surveyed (UK, Netherlands, Germany, France, Italy, Spain, Ireland) or in indeed Norway—a non-EU member state.

Views on climate change impacts, including those in the oceans tend to be heavily influenced by messages conveyed in the media. Sampei and Aoyagi-Usui (2009) showed that public opinion and concern can be quickly modified by television campaigns or newspaper coverage, and hence national attitudes will depend on levels of access to different media sources in different countries. Sampei and Aoyagi-Usui (2009) analyzed Japanese newspaper coverage of global warming from January 1998 to July 2007 and how public opinion was subsequently influenced. They showed that a dramatic increase in newspaper coverage from January 2007 onwards correlated with a significant increase in public concern for the issue. In the present survey we detected substantially different levels of usage and trust in different media sources among the 10 European countries. Television was the medium most-used by European citizens to provide information about climate change in the seas and oceans, and also the most trusted. Newspapers were trusted by citizens in some nations (e.g., UK, France, Czech Republic), more than in others, whereas the internet was trusted more in Estonia, Italy, Czech Republic and Germany than in other nations. Television use was negatively correlated with ocean knowledge in a study conducted in the Pacific Northwest (Steel et al., 2005). Newspaper use, on the other hand, was positively correlated with policy-relevant knowledge in both Michigan and the Pacific Northwest studies (Steel et al., 2005).

Levels of trust will depend on local experiences and perceptions—for example public broadcasters are often viewed as providing a reliable and impartial perspective on scientific and environmental issues whereas certain newspapers are perceived as promoting an overtly climate-change skeptic and anti-scientific agenda that is heavily dictated by the political leanings of their proprietors. Similarly, Brossard et al. (2004) presented a cross-cultural comparison of newspaper coverage of global warming in France and in the United States (1987–1997). These authors showed that France’s coverage was more event-based, focused more on international relations, and presented a more restricted range of viewpoints on global warming than American coverage did. American coverage emphasized conflicts between scientists and politicians and that this heavily influenced public perceptions of such issues in these countries.

Recent events such as the widely-reported “Climate gate” controversy in November 2009 (whereby a computer server at the UK Climatic Research Unit was accessed, and conversations among climate scientists released) have also been shown to have shaped public attitudes in certain countries, although in our own survey 18% of all respondents said climate change was the most serious problem facing the world. This was broadly similar to the proportion in a previous large scale study conducted amongst all 27 EU countries in 2009 (European Commission, 2009), i.e., before the “Climate gate” story broke. Leiserowitz et al. (2012)

reported on surveys conducted in 2008 and 2010 in the UK and US and found significant declines in Americans' climate change beliefs, risk perceptions, and trust in scientists. The loss of trust in scientists, however, was primarily among individuals with a strongly individualistic worldview or politically conservative ideology.

A key question arising from the present study relates to whether or not anyone communicating messages about marine climate change should try to target/tailor their messaging toward the most trusted or widely used media sources in each country. A comprehensive body of research has now built up, offering advice on communication strategies for climate change science (e.g., Moser and Dilling, 2011; Patt and Weber, 2014). The main conclusion from these studies seems to be that "Better understanding the audience will help identify the most appropriate framings, messengers, and messages that will most powerfully resonate with different people. Audience-specific use of communication channels may in the end be more cost-effective than mass communication that speaks to no one really" (Moser and Dilling, 2011).

Regarding the communication of environmental issues and risks, the public tend to mistrust governments, businesses, industry and sometimes experts, although governments are concurrently conferred a high degree of responsibility for solving these problems (Lorenzoni and Pigeon, 2006). Poortinga and Pidgeon (2003) conducted a survey of 1547 British respondents to determine who citizens trust most from a list of organizations/people to tell the truth about climate change. The highest levels of trust were ascribed to environmental scientists, environmental organizations (NGOs), university scientists and family/friends. The lowest levels of trust were ascribed to commercial companies, the EU and government. Strikingly similar patterns were apparent in our own survey of European citizens. Notably in both studies, government and industry supported scientists scored significantly lower in terms of trust compared with university scientists and those supported by NGOs.

In the present study marked differences in levels of trust and distrust were apparent for different countries. Distrust in industry was high in Germany but low in France. Citizens of the Czech Republic and Ireland were most likely to distrust their national governments, whilst the Dutch and Norwegians were least likely to do so. The observation that Dutch citizens were among the most likely to trust their national government and among the least worried about coastal flooding and sea level rise is particularly interesting given the low-lying nature of this country and the long history of catastrophic flooding. However, this finding has been reported in previous European polling exercises, and was borne out in a series of face-to-face interviews with Dutch citizens carried out under the CLAMER programme (i.e., the same EU Framework 7 project, that funded the work reported here). In the Netherlands, major government investments have been made since catastrophic floods occurred in 1953, and a comprehensive "Delta Works" programme was introduced that involves ongoing risk assessment and enhancement of engineering structures (e.g., dikes, dams, sluices, levees, and flood barriers etc.). In addition, policy measures

including the "Flood Defense Act" (1995), "Water Act" (2009), and the "Delta Act" (2012) prescribe safety levels with regard to flooding and protection of the coastline at 1990 levels and are enshrined in law to protect Dutch citizens (Kwadijk et al., 2010).

## Differences in Views and Awareness among Demographic Categories

It is widely known that demographic factors (e.g., age, education and gender) can influence self-declared levels of awareness or concern in public polling studies (e.g. Klineberg et al., 1998), and this was apparent in the own results reported here. Females, coastal dwellers and older people typically expressed higher levels of concern across all of the topics discussed.

Potts et al. (2016) found that populations across all age groups were concerned about climate change more than the health of the marine environment, with little difference between age cohorts (exceptions being older generations in the UK, France and Germany). However, for concern about the marine environment specifically, Potts et al. (2016) detected statistically significant differences between generations, with concern increasing with age. Klineberg et al. (1998) found that the two demographic variables correlate most with environmental concerns were age and education. However, other variables such as ethnicity, religiosity and gender were also important. In our own study, there was a slight tendency for more people in the older age groups to suggest that climate change is primarily caused by natural processes, and equally slightly more people in the youngest age groups suggested that humans are mainly or entirely responsible. Older people expressed more concern than younger people, especially those in the 55–64 age bracket compared to 18–34-year-olds. The youngest age group (18–24) tended to prioritize policies associated with reducing the amount of CO<sub>2</sub> in the atmosphere more than older age groups, whereas the oldest groups were more likely to say that improving coastal defense was a priority compared to younger age groups. With regard to sources of information 18–24 year olds were the biggest users of the internet, films and social networking sites, although they tended to trust these sources much less than older age groups.

Social science research shows that that survey respondents can often overstate both their level of knowledge and their concern about any issue put to them. Consequently, our results should be interpreted as a broad ranking of the extent to which citizens feel informed. Many people felt quite well informed about highly-publicized issues such as melting Arctic sea ice (48%), pollution (47%), and overfishing (45%), but claimed to know much less about more complex issues such as ocean acidification or impacts on wildlife. McCright (2010) examined theoretical arguments about gender differences in scientific knowledge and environmental concern using 8 years of Gallup data on climate change knowledge and concern in the US general public. Consistent with much existing research, women typically underestimated their climate change knowledge more than men. Also, women expressed slightly greater concern about climate change than men, and this gender divide is not accounted for by

differences in key values and beliefs or in the social roles that men and women perform in society (McCright, 2010).

In our survey, men considered themselves better informed about most of the topics in comparison with women, however females expressed higher levels of concern across all of the topics discussed. In addition, more women than men in our survey said that impacts of climate change in the seas and oceans were already happening, but more men than women reported distrusting all media types: for example, 46% of men expressed distrust of tabloid newspapers compared to 41% of women. By contrast, 65% of women reported that they trusted what they learnt from television compared to 54% of men.

### Proximity to, and Familiarity with the Sea

In our survey, we attempted to determine whether levels of awareness and concern as well as knowledge and opinions differed between those living near to the coast and those living inland. In our analysis respondents living in coastal areas claimed to be both more informed and more concerned than those living inland, for all issues considered. In particular, coastal respondents declared themselves to be far more informed about coastal erosion in comparison with European citizens that live inland. Potts et al. (2016) carried out a similar assessment and found that concerns over the health of the marine environment or climate change did not vary greatly according to the distance that people live from the coast, with either weak or non-significant relationships.

Some previous studies have focused on perceptions of risk near the coastline. For example, Brody et al. (2008) showed in the U.S. that risk from climate change is perceived to be significantly lower for respondents located farther away from the coastline. Flooding experience has been found to correlate with higher concern about climate change and belief in the efficacy of individual behaviors (Spence et al., 2011). However, evidence with regards to the influence of direct experience on engagement with climate change is contradictory: some studies suggest that direct exposure enhances the connection with, and awareness of, climate change risks (see Spence et al., 2011; Chilvers et al., 2014), whilst other empirical work does not support this relationship (e.g., Whitmarsh, 2008).

Milfont et al. (2014) carried out a survey of 5,815 citizens in New Zealand. These authors found that people living in closer proximity to the shoreline expressed greater belief that climate change is real and greater support for government regulation of carbon emissions. This proximity effect held when adjusting for height above sea level and regional demographics (accepting that wealthier people tend to live nearer to the sea).

### Awareness of Magnitude and Rates of Change

To understand more about public awareness of the *impacts* of climate change on the marine environment in Europe, respondents were asked about the magnitude and rate of change for two fundamental issues, sea temperature change and sea level rise. Broadly speaking, the estimates provided by the public accorded well with expert opinion. Steel et al. (2005) conducted a similar “test” of ocean knowledge among citizens in the

US, making use of three general indicators, including: (1) self-assessed level of informedness; (2) familiarity with a number of specific terms and concepts; (3) correct answers recorded to five questions concerning ocean resource issues. The main conclusion from our own study is that the populace throughout Europe (even in land-locked countries such as the Czech Republic) are relatively well-informed about most marine climate change issues.

Previous research on public knowledge concerning ocean conditions has revealed that while there is a general realization that ocean and coastal areas may be “in trouble” due to pollution, over-fishing, etc., the public knows little about ocean functions and ecology (Steel et al., 2005). Similarly, a 2003 survey commissioned by the AAAS found widespread concern among the public for coastal regions and ocean health, but also found that only 31 percent of respondents knew that their personal behaviors had an impact on the health of oceans and coastal areas (see Steel et al., 2005). While the results from our European survey are hopeful, in the sense that they demonstrate some basic awareness of key issues, as well as realistic perceptions about rates and magnitudes, certain issues (such as ocean acidification) clearly have less salience (Frisch et al., 2015; Capstick et al., 2016), and it remains unclear whether stated levels of concern will translate into demands for action at the personal or political level. Enhancing public awareness and knowledge has been viewed as essential in order to increase public support for sustainable management of maritime environments in the longer-term. Steel et al. (2005) found that citizens knowledgeable about ocean conditions were most supportive of ocean and coastal protection.

### Potential Biases of the Survey Design

Although we have tried hard to ensure that the survey design employed here, is as robust as possible, there remain possibilities that the results could have been influenced by the way that the survey was conducted or that particular questions were phrased.

Schuldt et al. (2015) has demonstrated that disparities in the results of climate change opinion polls may be greatly exaggerated by questionnaire design variables. These authors examined the effects of question wording and order on the belief that climate change exists in the United States, as well as perceptions of scientific consensus, and support for limiting greenhouse gas emissions. In the present study, all questions needed to be translated into 10 different European languages, and thus it is possible that subtleties of meaning and understanding were different in each of the countries surveyed. In order control for this eventuality, we employed a professional polling country (TNS-Opinion) that was very accustomed to conducting large-scale pan-European surveys (given that they oversee the annual “Eurobarometer” survey). Questionnaires were designed by the project team, translated by TNS-Opinion, but then checked by native speakers with a marine science background from each country, to ensure that the original meanings and nuances had not been lost. This highlighted a number of translation problems that were subsequently corrected.

A further potential bias could be related to the fact that the survey was conducted online, using existing panels of respondents maintained by TNS, whereas not all European

citizens have access to, or make wide usage of the internet. Recent demographic statistics indicate that on average, in Europe, 78% of households have internet access at home, but this varies from country to country (Potts et al., 2016). A considerable body of research has been conducted comparing internet-based methodologies and face-to-face interviews. Baek et al. (2011) conducted a survey of views in the United States and found that online deliberation typically over-represents young, male, and white users, attracts more ideological moderates, generates more negative emotions, and is less likely to result in consensus regarding climate change and political action in comparison with face-to-face deliberation. We have attempted to control for such factors by using a randomly stratified selection in each country according to age, sex, and region.

Ideally it would have been possible to “drill down” in each country using face-to-face focus-groups, to better understand reasoning and differences behind the responses emerging from the 1,000 citizens examined in each case. Unfortunately, this was not possible for financial and logistical reasons, however such a “citizens-panel” was convened in the United Kingdom to accompany this survey and the results of this exercise have been fully described by Chilvers et al. (2014).

## CONCLUSIONS

This pan-European survey provides a unique, detailed view of the opinions of over 10,000 European citizens on what marine climate change issues they know and care about. The main conclusions are as follows:

1. European citizens clearly care about climate change, ranking it second in a list of major global issues. Most people believe that climate change is at least partly caused by humans and that marine climate change poses an immediate threat. However, the public is generally more concerned about other coastal and marine issues that are not directly linked to climate change (e.g., pollution, over-fishing and habitat destruction). However, some climate change impacts, such as sea level rise and flooding, also score highly.
2. The European populace declare themselves as being well informed with regard to many marine climate change issues (the exception being ocean acidification) and this was confirmed by simple “tests” of awareness and magnitude, and temporal proximity of climate change effects.
3. Citizens in different countries vary in terms of their levels of awareness, concern, favored sources of climate change information and trust in media, organizations and government. Some countries always express high concern about marine environmental topics (e.g., Italy), whereas others are characteristically less concerned (e.g., Norway, Estonia and the Netherlands). Some countries are more trusting of information sources or organizations (e.g., Italy) others are more suspicious (e.g., Germany and the Netherlands).
4. This study confirms earlier research in suggesting that European citizens who live near the coast are typically more

concerned and informed about marine climate change issues, compared to those who live inland. Furthermore, women are typically more concerned—but declare themselves as being less informed than men. Concern but also trust increases with age. Eighteen to Twenty-four year olds are the biggest users of the internet, films and social networking sites as sources of information but are typically less likely to trust these sources.

5. Scientists should consider where the public in different countries or demographic groups get their information from and why citizens form the opinions they do. Where possible scientists and policy makers should target correspondence and communication on the most trusted and used media sources, being aware that certain types of scientist are more trusted than others.
6. In terms of policy actions and interventions, most respondents highlighted climate change mitigation measures as opposed to local-scale adaptation. Younger participants tended to prioritize actions associated with reducing carbon emissions, whereas older age groups tended to prioritize improving coastal defenses. Successful adaptation to the impacts of climate change requires public engagement, and support for policy decisions.

## AUTHOR CONTRIBUTIONS

PB and JP contributed to the design and implementation of the study, analytical tools, the project report, and wrote this manuscript. GT, JC, IL and SG contributed to the design and implementation of the study, the project report, and manuscript. SG and CD contributed to data analysis, and the final project report. SP provided the overall lead on manuscript preparation, review and submission.

## ACKNOWLEDGMENTS

The authors would like to thank Anna Dudek and Anabella Arquati from TNS Opinion for their help and assistance in running the polling study across 10 European countries. We would also like to express our sincere thanks to the Cefas staff members who helped us to translate more than 30,000 “free responses” in 10 different languages. The research reported on in this paper formed part of the Climate Change and European Marine Ecosystem Research (CLAMER) project funded under the EU’s Seventh Framework Program (FP7-2009-1-244132). PB and JP would like to thank the UK Department for Environment, Food and Rural Affairs (Defra) and the Marine Climate Change Impacts Partnership (MCCIP) for supporting participation and the Defra project MINERVA (Maritime Industries-Environmental Risk and Vulnerability Assessment) ME5213 for supporting the write-up.

## SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <http://journal.frontiersin.org/article/10.3389/fmars.2017.00206/full#supplementary-material>

## REFERENCES

- Adelle, C., and Withana, S. (2008). *EU and US public perceptions of environmental, climate change and energy issues. Institute for European Environmental Policy*. Available online at: [http://www.ieep.eu/assets/382/eu\\_us\\_public\\_perceptions.pdf](http://www.ieep.eu/assets/382/eu_us_public_perceptions.pdf)
- Agresti, A. (2002). *Categorical Data Analysis, 2nd Edn*. New York, NY: John Wiley & Sons.
- Baek, Y. M., Wojcieszak, M., and Delli Carpini, M. X. (2011). Online versus face-to-face deliberation: Who? Why? What? With what effects? *New Media Soc.* 14, 363–383. doi: 10.1177/1461444811413191
- Brechin, S. R. (2003). Comparative public opinion and knowledge on global climatic change and the Kyoto Protocol: the US versus the rest of the World? *Int. J. Sociol. Soc. Policy* 23, 106–134. doi: 10.1108/01443330310790318
- Brody, S. D., Zahran, S., Vedlitz, A., and Grover, H. (2008). Examining the relationship between physical vulnerability and public perceptions of global climate change in the United States. *Environ. Behav.* 40, 72–95. doi: 10.1177/0013916506298800
- Brossard, D., Shanahan, J., and McComas, K. (2004). Are issue-cycles culturally constructed? A comparison of French and American coverage of global climate change. *Mass Commun. Soc.* 7, 359–377. doi: 10.1207/s15327825mcs0703\_6
- Brown, S., Nicholls, R. J., Woodroffe, C. D., Hanson, S., Hinkel, J., Kebede, A. S., et al. (2013). “Sea-level rise impacts and responses: a global perspective,” in *Coastal Hazards*, Vol. 1000 (Coastal Research Library: Springer Netherlands), 117–149.
- Brulle, R. J., Carmichael, J., and Jenkins, J. C. (2012). Shifting public opinion on climate change: an empirical assessment of factors influencing concern over climate change in the U.S., 2002 – 2010. *Clim. Change* 114, 169–188. doi: 10.1007/s10584-012-0403-y
- Capstick, S., Pidgeon, N. F., Corner, A. J., Spence, E., and Pearson, P. N. (2016). Public understanding in Great Britain of ocean acidification. *Nat. Clim. Change* 6, 763–767. doi: 10.1038/nclimate3005
- Capstick, S., Whitmarsh, L., Poortinga, W., Pidgeon, N., and Upham, P. (2015). International trends in public perceptions of climate change over the past quarter century. *WIREs Clim. Change* 6, 35–61. doi: 10.1002/wcc.321
- Cava, F., Schoedinger, S., Strang, C., and Tuddenham, P. (2005). *Science Content and Standards for Ocean Literacy: A Report on Ocean Literacy*. Available online at: [http://www.coexploration.org/oceanliteracy/documents/OLit2004-05\\_Final\\_Report.pdf](http://www.coexploration.org/oceanliteracy/documents/OLit2004-05_Final_Report.pdf), (Accessed 24 March 2017)
- CEC (2008). *Attitudes of European Citizens Towards the Environment*. Eurobarometer Special Report 295 Wave 68.2, TNS Opinion and Social, European Commission.
- Chilvers, J., Lorenzoni, I., Terry, G., Buckley, P., and Pinnegar, J. K. (2014). Public engagement with marine climate change issues: (Re) framings, understandings and responses. *Global Environ. Change* 29, 165–179. doi: 10.1016/j.gloenvcha.2014.09.006
- European Commission (2009). *European Attitudes Towards Climate Change*. Special Eurobarometer 322. Available online at: [http://ec.europa.eu/public\\_opinion/archives/ebs/ebs\\_322\\_en.pdf](http://ec.europa.eu/public_opinion/archives/ebs/ebs_322_en.pdf), (Accessed 4 March 2010).
- European Opinion Research Group (EORG) (2002). “The attitudes of Europeans towards the environment,” in *Eurobarometer 58.0 for Directorate-General Environment—Survey Managed and Organised by Directorate-General Press and Communication “Public Opinion Analysis.”* Available online at: [http://ec.europa.eu/commfrontoffice/publicopinion/archives/ebs/ebs\\_180\\_en.pdf](http://ec.europa.eu/commfrontoffice/publicopinion/archives/ebs/ebs_180_en.pdf) (Accessed 20 October 2005)
- Frisch, L. C., Mathis, J. T., Kettle, N. P., and Trainor, S. F. (2015). Gauging perceptions of ocean acidification in Alaska. *Marine Policy* 53, 101–110. doi: 10.1016/j.marpol.2014.11.022
- 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. U.S.A.* 111, 15042–15047. doi: 10.1073/pnas.1417344111
- Gelman, A., and Hill, J. (2006). *Data Analysis using Regression and Multilevel/Hierarchical Models*. New York, NY: Cambridge University Press.
- Heip, C., Grehan, A., She, J., Barange, M., Tréguer, P., Wassmann, P., et al. (2011). *Climate Change and Marine Ecosystem Research: CLAMER Synthesis of European Research on the Effects of Climate Change on Marine Environments*. Marine Board Special Report.
- IPCC (2013). “Summary for policymakers,” in *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, eds T.F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (Cambridge, UK; New York, NY: Cambridge University Press).
- IPCC (2014a). “Climate change 2014: impacts, adaptation, and vulnerability. part a: global and sectoral aspects,” in *Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, eds C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, et al. (Cambridge, UK; New York, NY: Cambridge University Press), 1132.
- IPCC (2014b). “Climate change 2014: impacts, adaptation, and vulnerability. part b: regional aspects,” in *Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* eds V. R. Barros, C. B. Field, D. J. Dokken, M. D. Mastrandrea, K. J. Mach, T. E. et al. (Cambridge, UK; New York, NY: Cambridge University Press), 688.
- Jefferson, R. L., Bailey, I., Laffoley, D., Richards, J. P., and Attrill, M. J. (2014). Public perceptions of the UK marine environment. *Marine Policy* 43, 327–337. doi: 10.1016/j.marpol.2013.07.004
- Kahan, D. M., Peters, E., Wittlin, M., Slovic, P., Larrimore Ouellette, L., Braman, D., et al. (2012). The polarizing impact of science literacy and numeracy on perceived climate change risks. *Nat. Clim. Change* 2, 732–735. doi: 10.1038/nclimate1547
- Klineberg, S. L., McKeever, M., and Rothenbach, B. (1998). Demographic predictors of environmental concern: it does make a difference how it's measured. *Soc. Sci. Q.* 79, 734–753.
- Kwadijk, J. C. J., Haasnoot, M., Mulder, J. P. M., Hoogvliet, M. M. C., Jeuken, A. B. M., van der Krogt, R. A. A., et al. (2010). Using adaptation tipping points to prepare for climate change and sea level rise: a case study in the Netherlands. *WIREs Clim. Change* 1, 729–740. doi: 10.1002/wcc.64
- Lee, T. M., Markowitz, E. M., Howe, P. D., Ko, C.-Y., and Leiserowitz, A. A. (2015). Predictors of public climate change awareness and risk perception around the world. *Nat. Clim. Change* 5, 1014–1020. doi: 10.1038/nclimate2728
- Leiserowitz, A. A., Maibach, E. W., Roser-Renouf, C., Smith, N., and Dawson, E. (2012). Climategate, public opinion, and the loss of trust. *Am. Behav. Sci.* 57, 818–837. doi: 10.1177/0002764212458272
- Lorenzoni, I., and Pigeon, N. F. (2006). Public views on climate change: European and USA perspectives. *Clim. Change* 77, 73–95. doi: 10.1007/s10584-006-9072-z
- Malka, A., Krosnick, J., and Langer, G. (2009). The association of knowledge with concern about global warming: trusted information sources shape public thinking. *Risk Anal.* 29, 633–647. doi: 10.1111/j.1539-6924.2009.01220.x
- McCright, A. M. (2010). The effects of gender on climate change knowledge and concern in the American public. *Popul. Environ.* 32:66. doi: 10.1007/s11111-010-0113-1
- Met office (2014). *The Recent Storms and Floods in the UK*. UK Met Office, Exeter, 27pp. Available online at: [www.metoffice.gov.uk/media/pdf/n/i/Recent\\_Storms\\_Briefing\\_Final\\_07023.pdf](http://www.metoffice.gov.uk/media/pdf/n/i/Recent_Storms_Briefing_Final_07023.pdf)
- Milfont, T. L., Evans, L., Sibley, C. G., Ries, J., and Cunningham, A. (2014). Proximity to coast is linked to climate change belief. *PLoS ONE* 9:e103180. doi: 10.1371/journal.pone.0103180
- Moser, S. C., and Dilling, L. (2011). “Communicating climate change: closing the science-action gap,” in *The Oxford Handbook of Climate Change and Society*, eds J. S. Dryzek, R. B. Norgaard, and D. Schlosberg. doi: 10.1093/oxfordhb/9780199566600.003.0011
- Patt, A. G., and Weber, E. U. (2014). Perceptions and communication strategies for the many uncertainties relevant for climate policy. *WIREs Clim. Change* 5, 219–232. doi: 10.1002/wcc.259
- Poortinga, W., and Pidgeon, N. F. (2003). *Public Perceptions of Risk, Science and Governance—Main Findings of a British Survey on Five Risk Cases*. Technical Report, University of East Anglia, Centre for Environmental Risk, Norwich.
- Potts, T., Pita, C., O'Higgins, T., and Mee, L. (2016). Who cares? European attitudes towards marine and coastal environments. *Marine Policy* 72, 59–66. doi: 10.1016/j.marpol.2016.06.012
- Reiner, D. M., Curry, T. E., de Figueiredo, M. A., Herzog, H. J., Ansolabehere, S. D., Itaoka, K., et al. (2006). American exceptionalism? Similarities and differences

- in national attitudes toward energy policy and global warming. *Environ. Sci. Technol.* 40, 2093–2098. doi: 10.1021/es052010b
- Sampei, Y., and Aoyagi-Usui, M. (2009). Mass-media coverage, its influence on public awareness of climate-change issues, and implications for Japan's national campaign to reduce greenhouse gas emissions. *Global Environ. Change* 19, 203–212. doi: 10.1016/j.gloenvcha.2008.10.005
- Schuldt, J. P., Roh, S., and Schwarz, N. (2015). Questionnaire design effects in climate change surveys: implications for the partisan divide. *Ann. Am. Acad. Politic. Soc. Sci.* 658, 67–85. doi: 10.1177/0002716214555066
- Shi, J., Visschers, V. H. M., Siegrist, M., and Arvai, J. (2016). Knowledge as a driver of public perceptions about climate change reassessed. *Nat. Clim. Change* 6, 759–762. doi: 10.1038/nclimate2997
- Spence, A., Poortinga, W., Butler, C., and Pidgeon, N. (2011). Perceptions of climate change and willingness to save energy related to flood experience. *Nat. Clim. Change* 1, 46–49. doi: 10.1038/nclimate1059
- Steel, B. S., Smith, C., Opsommer, L., Curiel, S., and Warner-Steel, R. (2005). Public ocean literacy in the United States. *Ocean Coast. Manag.* 48 97–114. doi: 10.1016/j.ocecoaman.2005.01.002
- Taylor, A., Bruin, W. B., and Dessai, S. (2014). Climate change beliefs and perceptions of weather-related changes in the United Kingdom. *Risk Anal.* 34, 1995–2004. doi: 10.1111/risa.12234
- Terry, G., and Chilvers, J. (2011). *Understanding Public Engagement with Marine Climate Change Impacts: Literature Review and Report of Qualitative Study*. School of Environmental Sciences, University of East Anglia. E. N. V.2009.1.1.6.3, F. P.7-2009-1-244132.
- TNS Opinion and Social (2005). *Attitudes of Europeans towards the Environment. Special Eurobarometer 127 for the European Commission, Directorate-General Press and Communication, Opinion Polls*, Available online at: [http://ec.europa.eu/comfrontoffice/publicopinion/archives/ebs/ebs\\_217\\_en.pdf](http://ec.europa.eu/comfrontoffice/publicopinion/archives/ebs/ebs_217_en.pdf) (Accessed 4 October 2005).
- Tobler, C., Visschers, V. H. M., and Siegrist, M. (2012). Consumers' knowledge about climate change. *Clim. Change* 114, 189–209. doi: 10.1007/s10584-011-0393-1
- Whitmarsh, L. (2008). Are flood victims more concerned about climate change than other people? The role of direct experience in risk perception and behavioural response. *J. Risk Res.* 11, 351–374. doi: 10.1080/13669870701552235
- Wordle (2017). Viewed 13/04/2017. Available online at: <http://www.wordle.net/>
- Conflict of Interest Statement:** 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.
- Copyright © 2017 Buckley, Pinnegar, Painting, Terry, Chilvers, Lorenzoni, Gelcich and Duarte. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) or licensor are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.