A vast amount of European research concerned with marine climate change issues has been done in recent decades. The results of this research show beyond reasonable doubt that climate change has already impacted on all of the oceans and seas of Europe and beyond, as summarised in the CLAMER (Climate change and European marine ecosystem research) synthesis report. This state of the art overview includes physical changes such as sea-level rise, sea temperature increase and stratification throughout the European marine regions. It also shows changes in abundance and distribution of marine organisms and populations, such as cod and herring populations which have extended northward and
But how much of this information is reaching the public? The CLAMER poll was conducted across 10 European nation states to assess the public knowledge and opinions on marine climate change issues. The results show that public estimates for rates of sea level rise and temperature change match well with scientific consensus, suggesting the European public are aware of some of the fundamental messages. However, there was relatively low awareness about oceans becoming more acidic, despite ocean acidification being a major EU research theme. This may be due to the fact that this particular issue is less 'visible' than some of the other climate related impacts listed and it is unclear as to how and whether this long-term change will impact people's daily lives.

Another possibility is that this limited knowledge is the result of a lack of communication effort from the experts and funding organisations that are in the know. According to the CLAMER outreach evaluation report, most of the 64 European Union (EU) research projects examined engaged in some sort of information campaign or public outreach activity. However, this did not usually extend beyond one-way imparting of knowledge through project websites, brochures, scientific papers or conferences. This is contrary to the key message of several sociological and communication studies reviewed by the CLAMER literature review, which is that scientific information about marine climate change needs to be presented in such a way as to create engagement, rather than merely to 'increase public knowledge'. Future projects are advised to acknowledge that there is diversity among the public and be sensitive to how the public understand and engage with marine climate change issues. They are advised to learn from some of the better outreach examples (e.g. Cape Farewell, HERMES and EPOCA) and make more attempts to involve members of the public and stakeholders directly.

CLAMER itself has attempted to reach a wide range of audiences via interactive events at aquaria throughout Europe, the CLAMER film, 'Living with a Warming Ocean', the CLAMER booklet and policy briefing fact sheets. As a consequence, it is hoped that all sectors including public, policy-maker and industry will be stimulated to take actions now to limit and adapt to climate changes.

In addition, CLAMER has shown that despite an EU-funding contribution towards relevant projects totalling over EUR 300 million since 1998, major gaps in marine climate change research still exist. The CLAMER synthesis report has highlighted the areas lacking attention both regionally by European basin and by research theme. Future research should be prioritised to address these issues in an efficient and collaborative manner.

Project context and objectives:

It is now commonly accepted that climate change poses one of the main challenges faced by society in the coming decades. Changes in patterns of air temperature, precipitation, extreme weather events and the impacts of such changes on terrestrial environments, often form the focus of public and political concern. The marine environment and marine ecosystems are also being impacted by climate change, with consequent impacts on all terrestrial environments (not just coastal) and thus on society itself. Although
there is no certainty regarding the precise nature and rate of future climate change, even the more moderate of the predicted scenarios is expected to further alter the marine environment, with major environmental, economic and social consequences.

Scientific research has contributed to a significantly improved knowledge and understanding of the current and future potential impacts of climate change on the marine environment. But those charged with making difficult decisions on whether and how to implement measures to adapt to the inevitable changes which are taking place, need access to the best scientific knowledge, translated into a format that they can understand and use.

Moreover, mitigation programmes, action plans and adaptive management systems that address climate impacts on marine environments, all depend on public engagement (Higgason and Brown, 2009). The general public need to understand the risks and implications of climate change impacts and effective communication is needed to incentivise public changes in individual behaviour designed to mitigate climate change, adapt to its impacts and support environmental resilience. Only through adequate knowledge and understanding of the potential consequences of climate change will the public support climate mitigation policies and adaptation measures, which may require significant investments of public funds. Understanding more about how the public view climate change's impacts on the marine environment and the underlying psychological, social and other factors is crucial to understanding how communication of the subject can best be achieved.

To these ends, the Climate change and European marine ecosystem research (CLAMER) project aimed to map and synthesise the research findings of recent and projected climate change impacts on marine ecosystems in Europe. It also set out to determine how the European public perceive, engage with and respond to possible climate change impacts on their seas and beaches and to identify public communication techniques that are effective in increasing public understanding.

The CLAMER project was instigated on the premise that a possible deficit existed between levels of scientific knowledge in this area and that of public awareness. The resulting ultimate goals of CLAMER were to highlight areas of European marine and climate change research that require attention and encourage societal adaptation and change by citizens of Europe and the world, via improved scientific communication to the public and policy makers alike.

Primary objectives

The CLAMER project was a collaboration between 21 institutes from across Europe. During its short term of 18 months, the project completed five important in-depth reports and various dissemination activities, which were centred around the three broad CLAMER aims as follows:

1. catalogue recent European projects concerned with European marine climate change issues and summarise resulting current scientific knowledge, primarily for the scientific and policy making communities.
2. assess public communication methods of past scientific projects and determine public perception in Europe regarding climate change issues and impacts on coasts and seas, with an eye to assessing
whether 1. has been effectively communicated and how public engagement with marine climate change impacts and other scientific topics can be improved.

3. disseminate the CLAMER findings to the public, policy makers and scientific communities.

Project methods

The project was made up of three work packages (WPs), plus a coordinating WP (WP0).

The 21 CLAMER contributing institutes were located throughout Europe and were supported by a Scientific Expert Panel (SEP, primarily for WP1) in addition to a number of external contributors, to aid in reviewing current and recent relevant scientific projects and literature and an Advisory Group to provide marine stakeholder feedback on a number of project outputs.

Information was primarily shared between project partners via email and the CLAMER project online portal. In addition, all four WPs convened together three times during the 18 month project to discuss overlapping themes and ways forward.

Project results

Key findings

The CLAMER inventory report contains summary information and contact details for a total of 92 pan-European projects, 79 of which were funded by EU the Fifth, Sixth and Seventh Framework Programmes (FP5, FP6 and FP7 respectively) and five international initiatives. It includes both past (dating back to 1998 to include FP5 and FP6) and current research with a focus on EU funded projects and programmes. Important non-EU funded pan-European, e.g. as funded by the European Research Area Networks (ERA-NETS) and projects under the ESF-Eurocores scheme, regional and international initiatives of relevance are also included in the overview. Together these projects boast broad-ranging and multidisciplinary research on how climate change affects marine systems at various spatiotemporal scales, ranging, for example, from long-term global effects of carbon dioxide (CO2) concentrations on the biosphere, to the immediate effects of local temperatures on the metabolism of bacteria.

The EU-funding contribution of the Framework Programme projects in this inventory alone totals well over EUR 300 million. These projects range from smaller one partner projects (e.g. for Marie Curie Actions) to large scale collaborative research projects with up to 74 partners from 20 different countries. Germany, France and United Kingdom are most frequently providing coordination of these EU project.

Limitations and future improvements

In many cases and for various reasons it proved difficult to source project information. For example, when a project was described in a project catalogue, the information was often incomplete or outdated. Additional information from project websites was often difficult to find, in particular in relation to project outputs and results and final project reports. Some notable exceptions include the FP Projects EuroOceans, Carboocean, Hermes/Hermione and international programmes such as CLIVAR and GLOBEC.
which maintain very informative project sites and which make project reports and other material readily availabe for download.

We can conclude that while there are many good examples of project websites and available information sources, often project results are not even available (or only fragmented) to other scientists. It is clear, therefore, that there is a poor flow or transfer of knowledge and findings from European Commission’s (EC) funded projects to end users and in particular to the public at large. This has been identified as a major constraint which needs to be addressed as a matter of urgency.

Recommendations for funding agencies resulting from the development of the CLAMER inventory report:

1. systematically and regularly compile and make available an overview of research funded by the EC Directorate General (DG) Research and Innovation on climate change impacts on the marine environment.
2. develop a clear, compulsory and formal mechanism for submitting and making available foreground information resulting from EU-funded research projects. This is needs to improve upon the current system of making available project information and outputs.
3. create one single well-branded report series which regularly publishes EU project descriptions and research results and task a responsible entity to manage it, either within or under supervision of the EC. Coordinators should be contractually obliged to provide contributions for the report series.
4. develop and manage a unique project referencing system which can be used by project researchers when they publish their results. This would create more visibility for the projects and EU investments while allowing research outputs associated with projects to be tracked more easily.
5. set up and widely advertise a self-regulating/updating EU project wiki as a new tool to submit, update and consult relevant EU-funded project information.
6. the EC Directorate General (DG) Research and Innovation needs to set the minimum information that is required on project websites and contractually oblige project coordinators to include this information. We recommend that project websites should contain at least key project data such as that provided for individual projects in this report (start/end of the project; funding source and amount; duration; project coordinator; etc.), the list of project partners with contact details of the researchers involved; and a description of the project with specific reference to its outputs. It is strongly recommended that all project deliverables should be made directly available on the project website.
7. contractually oblige project coordinators to maintain a project website, including gathered data, reports and dissemination products, for at least five years following completion of the project.
8. improve the coordination and thoroughly streamline potential new (e.g. EU project wiki) and the many already existing tools (project websites, catalogues, research magazines, project databases, etc) to generate a more efficient flow of information from EU-funded research to all stakeholders including other researchers, as well as research managers, policy makers and the public at large. This is needed to avoid duplication of effort and fragmented availability of the EU-funded research initiatives and their outputs.

Key findings from the CLAMER synthesis report

The CLAMER synthesis report illustrates beyond reasonable doubt that climate change has already impacted on all of the oceans and seas of Europe and beyond. It also identifies the clear variation in type and extent of impacts which can be found across Europe’s regional seas.
Most of the observed changes discussed in this report, thought to be predominantly a consequence of climate change, can be categorised as follows:

1. physical changes in the seas and oceans (e.g. sea-level rise, sea temperature increase and stratification)
2. melting of Arctic sea-ice and associated impacts (e.g. changes in the Arctic foodweb and trans-Arctic migrations)
3. changes in abundance and distribution of marine organisms and populations (e.g. fish, such as cod, haddock and herring, populations of which have extended northward and eastward at high latitudes)
4. shifts in seasonal migration patterns of marine species (e.g. shift from seasonal migration for spawning and feeding to overwintering of the fish species dorado (Sparatus aurata) and salema (Sarpa salpa) in a warming Black Sea)
5. cumulative effects of multiple stressors (e.g. impacts arising from, or compounded by, a combination of climate change, ocean acidification, hypoxia, fisheries and eutrophication); and
6. socioeconomic consequences of all of these changes (e.g. impacts on commercial fisheries and tourism, coastal inundation and erosion, etc.).

The CLAMER synthesis report concludes that in order to formulate better adaptive strategies to address the consequences of climate change, it will be essential to:

1. improve methods to reduce the uncertainty of climate change projections
2. ensure the accuracy of measurements and predictions by means of an integrated monitoring and observation network; and
3. further improve the exchange of knowledge within the scientific community and between scientists, policy makers and the public at large.

Research gaps and priorities per region

The Baltic Sea:

1. develop a system approach for Baltic Sea climate change research, which may include developing a fully coupled Baltic Sea earth system model (atmospherehydrological-catchment-ocean-ice-wave-biogeochemical-SPM-larvae-fish models), providing high quality multi-model coupled ensembles for the Baltic Sea climate simulations, investigating the stability and predictability of the system and developing scenario-based predictions in decadal and centennial scales;
2. further improve existing Baltic Sea observing systems for supporting the system approach of Baltic climate change research, especially for biogeochemical parameters;
3. improve understanding of existing Baltic Sea climate change processes and the relative importance of internal and external factors which will give a solid base for scenario-based predictions;
4. solve key issues in using ecological models for climate research such as the reconstruction of past ecosystem changes including regime shifts, development of ecosystem forecast at seasonal and decadal scales and integration of the internal budget balance in long-term ecological models.
The North Sea:

1. develop a better systematic observation and process understanding of atmospheric and oceanic parameters and increase the temporal and spatial coverage of monitoring and research on the major biotic components (plankton, benthos and fish);
2. improve global circulation models (GCMs) to capture the decadal (NAO) and multi-decadal (AMO) scale variations in ocean climate and develop regional downscaling models based on different GCMs;
3. extend biophysical modelling of single species beyond the egg and larval stages to better predict climate-driven changes on marine fish populations;
4. improve lower trophic level ecosystem models, placing more emphasis on pelagic-benthic coupling of marine systems and improve the linkages between models of the upper trophic web and biogeochemical and nutrient-phytoplankton-zooplankton-detritus (NPZD) models;
5. strengthen research efforts on the growth physiology of key species and their life stages, as well as on the physiological effects of acidification on multiple stressors.

The Arctic Ocean:

1. significantly improve the provision of basic data from key regions of the Arctic Ocean, in particular on lower trophic levels and processes and better seasonal and spatial coverage, to validate current models which must also be improved with regard to physical forcing;
2. improve pan-Arctic integration and holistic understanding of the circular Mediterranean-type Arctic Ocean, which implies increased coverage of ice strengthened research vessels, more emphasis on permanent instrumentation and an increased number of stations that can be used throughout the year;
3. improve knowledge on temperature-dependent respiration and metabolism at low temperatures and stage structured models for key zooplankton stages in order to simulate their ability to conquer new geographical areas;
4. develop a greater and better integrated and internationally coordinated research effort on the entire Arctic Ocean, e.g. through a joint action of the Arctic Council, the European Polar Board and/or International Arctic Science Committee (IASC);
5. improve the understanding of how physical and chemical oceanography shape the dynamics of ecosystems, determine the new and harvestable production and the biogeochemical cycling (including exchange with the atmosphere) and pelagic-benthic coupling;
6. develop management tools to evaluate the state of Arctic environments in relation to climate change and increased stress by a resource-demanding world economy.

The North Atlantic:

1. drastically improve the understanding and model predictability with regard to changes in ocean-atmosphere interactions and atmospheric teleconnection patterns, such as the Atlantic Multi-decadal Oscillation (AMO) and the North Atlantic Oscillation (NAO) and their potential effects on future climate change;
2. ensure that the North Atlantic is a key component of an integrated global ocean observing programme by addressing current perceived short-comings such as the lack of continuous time series of key ocean-climate variables which is preventing progress in modelling climate feedbacks;
3. improve biogeochemical models to take into account the full complexity of marine ecosystems, in particular in relation to the complex biodiversity and functioning of microbial systems and their feedback to biogeochemical cycles;

4. expand research on the impact of acidification to include non-calcifying organisms and ecosystem components and processes such as nutrient speciation and availability, trophic interactions, reproduction, metabolism, diseases, etc. which may impact on all organisms but most critically on primary producers;

5. improve the scientific basis for fisheries management through improved research and monitoring of fish stocks as part of the implementation of a whole ecosystem approach to understanding the effects of climate change.

The Mediterranean Sea:

1. improve the understanding of the impacts of climate change on the structural and functional biodiversity (including marine microbes and viruses), ecosystem services and biogeochemical cycles of the Mediterranean;

2. improve understanding of existing climate change features using the North Adriatic Sea and the Ligurian Sea Gulf of Lion as a reference for the impact of rising temperatures on the cold water Mediterranean regions;

3. improve knowledge of the present-day changes occurring in the deep-sea Mediterranean and their impacts;

4. implement identified Mediterranean sites investigated for the L-TER long-term ecological monitoring, including sites and observatories in the deep sea;

5. identify species and areas for environmental conservation in order to limit the impact of climate change on species with cold water affinity;

6. improve the understanding of the synergistic effect of direct anthropogenic impact and climate change on Mediterranean habitats and functions.

The Black Sea:

1. develop a better understanding of the interplay between the natural and anthropogenic impacts of climate change, coastal and interior basin ecosystems and the well-being of people by means of systematic observations;

2. improve monitoring of social and natural system indicators to develop reliable scenario models that will serve as a basis for designing appropriate management strategies and decision making processes towards sustainable use of ecosystem goods and services in the Black Sea, i.e. identifying ecosystem;

3. properties that are most vulnerable to abrupt and dramatic state changes in response to climate change and the climatic and ecological determinants of such changes; establishing which system properties can be used to forecast system resiliency, etc.

4. develop predictive models for a better understanding of how climate change and variations affect hydrographic structure and circulation (e.g. stratification, thermal regimes and current patterns) and their impacts on the nutrient and organic matter input, energy and nutrient exchanges, biological diversity, structure and function of the food web and primary and secondary production;

5. introduce a research programme on the impacts of acidification in the Black Sea.
Key findings on public perception and awareness

Most of the 64 EU projects examined, engaged in some sort of information campaign or public outreach activity and in some instances (although rarely) this was an integral part of the wider programme of work. However, in most cases outreach did not extend beyond one-way imparting of knowledge through project websites, brochures, scientific papers or conferences and there was little or no attempt to involve members of the public and stakeholders directly in data collection, or to gather views and opinions. Certain trends and developments in the scope of outreach activities were noted. For example the recent inclusion of social-networking websites (e.g. Facebook and Twitter) is among the arsenal of tools used by projects.

A number of projects were celebrated as examples of ‘good practice’ in terms of their imaginative outreach programmes, both in terms of breadth and diversity. For each of these, project communication was viewed as an integral component of the wider programme and not simply an afterthought or unfortunate requirement imposed on the project by the EC.

Key recommendations for future projects regarding outreach and communication

As a result of this CLAMER evaluation, 15 recommendations with regard to outreach programmes and communicating with the public, stakeholders and policy makers were developed:

1. A general requirement should be placed on all Marie Curie Intra-European Fellowship projects to provide at least some online content describing the nature of the collaboration and any outputs. Until this is achieved, such projects will continue to be virtually invisible to the public, stakeholders, policy makers and end-users in general.

2. Projects should aim to develop materials (preferably in multiple languages) that explain the science in a simplified form that can be used and accessed by students, school children and members of the public. Other engagement/outreach activities are encouraged (such as the schools and youth programmes of EPOCA, Eur-Oceans, MarBEF and Cape Farewell), although it is recognised that this will not be possible/desirable in every case.

3. More care should be taken on project websites to communicate ‘policy relevance’ or ‘stakeholder need’ for the particular scientific investigation. In particular, greater effort is required among projects focussing on oceanographic issues, the Arctic and long-term climate change, where it is often very difficult to deduce why such a project is useful, interesting and has been instigated in the first place.

4. Outreach and engagement should be viewed as an integral part of the wider programme and not simply an afterthought or unfortunate requirement imposed on the project by the EC. Adequate emphasis should be placed on such activities, even in small projects such as Marie Curie Intra-European Fellowships. Large integrated projects and networks should be expected to engage more fully in outreach with a well thought out strategy for dissemination in each case.

5. It can be useful to establish a designated ‘media centre’ for newspapers, television (TV) and radio to contact directly. Occasional ‘press releases’ can yield considerable media interest if they are carefully targeted and focus on topics that are likely to capture the public’s attention.

6. Exhibitions can be a useful route through which scientific projects can communicate with the public. Several of the 64 projects examined developed travelling exhibitions that were widely viewed at museums and public aquaria.
7. A clear recommendation must be that future EU research projects should engage more closely with members of the public, not only in a one-way information generation mode (as has usually been the case), but they should also employ more imaginative two-way interactive methodologies to engage the public in debate, data collection or digitisation as has been the case for some of the initiatives described above (see the section on ‘Feedback and Public Involvement’). As technology develops, the means through which scientists will be able to communicate with citizens will undoubtedly change and probably broaden.

8. Involvement or endorsement by artists, celebrities or politicians can enhance public interest in and the profile of, a particular project, though care needs to be taken such that scientists are not accused of political ‘lobbying’.

9. It can be helpful to establish a stakeholder advisory group (or Reference User Group) in order to ensure that project outputs are well-suited to the needs of end-users or policy makers; also, to act as a conduit for communicating messages to the wider world and stakeholder community. Members of such committees can act to ‘champion’ particular research project and thus ensure wider outreach/impact.

10. A clear and concise policy summary should be drafted at the end of each project outlining the level of scientific knowledge before and contrasting this with what has been learnt since (to demonstrate ‘value added’). This summary statement should explicitly identify any policy commitments/drivers that the project is intended to contribute towards and how policy makers are better off as a result of the new knowledge.

11. Project blogs, commentaries or diaries can be effective for communicating near real-time observations or activities, but in most cases lie dormant for many months and offer little in terms of outreach and engagement. Such high-maintenance techniques should only be attempted where there is an expectation that progress will be rapid or of interest to the general public. Expeditions and research cruises can represent a period of intense activity that is of wider interest, but otherwise social networking sites such as Facebook and Twitter may be more appropriate.

12. Social networking sites such as Facebook, Twitter and Bebo are increasingly becoming the route of choice for communicating with the public. Future projects are encouraged to consider using such techniques, especially associated with intense periods of activity such as expeditions, exhibitions or press launches.

13. Providing access to online project data can be a key component of any outreach strategy. A good approach can include uploading of data to open-access networks such as Pangaea or data visualisation through Google Earth. It seems highly likely that these approaches will become an increasingly common feature of research projects and proposals in the future.

14. Before commencing new projects, researchers should articulate the main goals and objectives for planned outreach activities. Desirable and measurable outcomes should be considered upfront, since this will determine the number, diversity and ambition of outreach activities required in the particular case.

15. A quantitative assessment of the effectiveness of particular outreach/education techniques employed by EU projects should be carried out, with the aim of identifying the optimum communication tools for imparting potentially complex research results to the general public. The content of this report would offer a solid starting point for such an evaluation.

Key findings from the CLAMER survey of public perception and awareness

Climate change versus other world problems:

1. at a broad level, the public regards climate change as one of the most important problems faced by
society, with almost a fifth of all respondents (18%) saying this issue is the most serious problem facing the world today, second only to 'poverty, lack of food and drinking water'

2. the United Kingdom (UK) and Czech Republic were slight exceptions to this rule, being the only countries where climate change did not rank as one of the top three global issues

3. older people (especially over 65) were less likely to say that climate change is the most serious problem facing the world today.

Causes of climate change:

1. the vast majority (88%) of the 10 000 respondents from across Europe thought that climate change was caused at least in part by human activity

2. some countries were more strongly convinced than others that humans were the dominant factor causing climate change: 60% of respondents from Spain believed that climate change is either 'mainly' or 'entirely' caused by human activity, compared to just 26% of respondents in Estonia. Almost as many Estonians (23%) thought that climate change was either 'mainly' or 'entirely' caused by natural processes.

Marine environment issues of concern:

1. when asked to identify, in their own words, three important environmental matters relating to the coastline or the sea, 'pollution' was by far the most important environmental matter cited. Only four 4% of responses included the phrase 'climate change'.

2. almost 19% of UK respondents and 16% from Ireland, saw 'coastal erosion' as an important environmental matter. However, 'coastal erosion' hardly showed up at all as an issue for respondents from the Czech Republic, Spain or Norway.

3. 'Fish stocks' / 'overfishing' was a much more common response in Germany and Norway (around 14%) than Estonia and Italy (less than 4%).

Marine climate change issues of concern:

1. when asked to provide spontaneous responses specifically on marine climate change issues, sea level rise featured most prominently, followed by a wide range of other issues (e.g. wildlife, erosion and flooding). In addition, 13% of responses answered either 'don't know' or 'nothing' suggesting that a significant proportion of respondents were struggling to name three marine climate change issues, while sea level rise was the most frequent response in Germany, France and Spain with coastal erosion coming out top in Ireland and the UK.

2. when subsequently provided with a prompted list of 15 marine environmental issues (including both climate and non-climate related issues) most respondents claimed to be well, or quite well informed about well-publicised 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.

3. when asked how concerned they were about the issues raised on this prompted list, there was generally a strong correlation between how informed respondents perceive themselves to be and then how concerned they were, although there were also some anomalies. This was particularly true for ocean acidification, with only 14% of people claiming to be well-informed about this issue, while 58% were concerned about it.
4. with regards to concern, sea pollution ranked highest of the 15 prompted issues and by a wide margin, across all ten countries. The next two marine environmental matters of concern were also non-climate related issues. However, some issues that relate more directly to climate change came very close behind, most notably melting sea ice, coastal flooding, sea level rise and changes in the frequency of extreme weather events.

5. females and older people were more concerned about the 15 issues covered.

Ocean literacy:

1. estimates provided by the public for rates of sea level rise and temperature change matched well with scientific consensus, suggesting some fundamental messages are getting through to the public domain.

2. there was relatively low awareness about oceans becoming more acidic, despite ocean acidification being a major EU research theme. This limited knowledge may be due to the fact that this particular issue seems less 'visible' than some of the other climate related impacts listed and it remains unclear how and whether this long-term change will impact people's daily lives.

Sources of information and trust:

1. with regards to sources from which respondents received information on marine climate change, television and the internet generally dominated although a surprisingly high proportion of respondents said they got their information through scientific publications.

2. trust in scientific publications as a source of information, was generally much higher than for all other forms of media although broadsheet newspapers, TV and books also scored fairly well. The public generally have most faith in scientists (although this is significantly lower for scientists working for government or industry), with non-governmental organisations (NGOs) also faring well, whilst the EU came some way down the list it is more trusted than local and national political bodies. Industry came at the bottom of the 'trusted' list.

Action bodies:

1. the patterns seen for levels of trust were mirrored in the poll results concerning the organisations and individuals perceived as effective at taking action. NGOs fared well, (along with community groups), the EU was seen as more effective than local and national governments and industry which came bottom.

2. across Europe, respondents felt they generally had more influence at the local than European level, although the difference was not that marked. Half of the respondents in France felt they could influence decisions at the EU level, a figure much higher than for all of the other countries polled.

Personal action and responsibility:

1. there is a marked disparity between what people claim would be the most effective means of helping to reduce or cope with the impacts of climate change and the actual actions they take in their everyday lives.

2. the actions people currently take appear to focus more on decisions as 'consumers', such as reducing energy use, buying environmentally friendly or locally sourced foods, reducing water use and taking holidays closer to home. However, such actions might equally be interpreted as relating to reducing
household expenditure (i.e. economic incentives) as opposed to concerted actions aimed at reducing environmental impact.

3. in terms of what people actually do, reducing energy use at home was fairly universal across the countries studied, although Norway comes out lowest (which is at odds with the fact that this scores highest when asked what people should do).

Priorities and awareness of policies and research theme:

1. when asked which marine and climate change policies should be prioritised by the EU, it was a non-climate change related option that was the clear favourite (namely 'tightening controls over chemicals that can be released into the sea'). The most popular climate change related options were associated with climate change mitigation (through reduction in atmospheric CO2) rather than understanding or reducing the effects of climate change.

2. in terms of awareness of 13 EU research themes, melting sea-ice stood out with almost half of all polled respondents having heard about this issue.

3. awareness of 10 of the 13 EU research themes was highest amongst the two oldest age groups (55+). People living in coastal areas had a higher awareness of issues relating to coastal erosion and marine and coastal management practices than those living inland.

4. there was a clear link between the research themes that respondents claimed they were most aware of and the top three research themes that they thought should be prioritised (e.g. 'melting sea-ice'). The exception to this was 'coastal erosion' which came further down the list of priorities. Conversely, studies on 'diseases and pests' and 'how communities can cope with climate change' were seen as being of high research priority, despite limited awareness of these issues.

Conclusions and recommendations:

1. there were many subtle differences across Europe with regard to perceptions, awareness and stated research priorities concerning climate change in the oceans and seas which the EU should take note of.

2. whilst understanding of some key topics is good (e.g. sea level rise), there is limited public awareness of some scientific issues (e.g. acidification), possibly reflecting a failure of communication in some instances (by scientists, project leaders, governments and policy makers). More emphasis is required on techniques to engage the public and on wider dissemination where awareness is lacking.

3. scientists should consider where the public get their information from (mostly television and the internet) and how citizens come to the opinions they do and thereby target correspondence and communication on the most trusted and used media sources (being aware that certain types of scientist are more trusted than others).

4. scientific topics that the public are interested in and prioritise as being important are not always the same as those that would be prioritised by policy makers, research funders and the scientists themselves. Marine climate change issues are typically viewed as being of lower priority and importance when compared with other marine environmental issues. The utility of certain research strands concerning climate change in the oceans and seas remain poorly understood and consequently are valued less than issues of immediate and recognizable threat to individuals and society.

5. public perception regarding climate change in the oceans and seas is almost universally negative, focusing on threats rather than any potential opportunities. Although climate change in general is
recognised as a serious threat to society, regarding the seas specifically, the 'tangible' issues related to pollution were by far of most concern.

Key findings and recommendations of the literature review

Prior studies of public engagement with marine climate change impacts in Europe have often been framed in terms of risks from sea-level rise and coastal flooding to vulnerable coastal communities, so by their nature they are concerned with adaptation to climate change impacts on marine environments. In this context, deliberative and participatory processes have been successful in exploring public views on the risks and the range of alternative responses. However, risk perceptions are only one aspect of possible public engagement with this topic. The CLAMER literature review shows that other types of public engagement, for instance based on personal morality, are as yet under-researched. In particular, there is an important need to explore the factors that foster interest and concern in impacts such as ocean acidification or sea temperature rise, which at present seem remote and irrelevant to many members of the public.

The key message of several studies reviewed here is that scientific information about marine climate change needs to be presented in such a way as to create engagement, rather than merely to increase public knowledge. There is a rich seam of research highlighting both how this might be done and what is counterproductive. Future marine climate change communications should take account of these valuable insights.

Key findings and recommendations of the qualitative survey

The findings of the qualitative study indicate that:

1. visibility and personal experience are important factors in the salience of climate change impacts on marine systems for individuals, their degree of concern and as a source of public knowledge about these issues.
2. for some individuals, concern does seem to be driven by risk perception.
3. other individuals however see marine climate change impacts as a moral issue, because of their effects on vulnerable people and species; they engage with the subject in a different way.
4. some members of the public have integrated and holistic views of marine climate impacts and tend to frame these and climate change in general as aspects of the wider problem of unsustainable societies rather than as discrete scientific issues.

Both the findings of this study and the literature review highlight the need to acknowledge such diversity among the public and target communications accordingly. Attempts to engage the public need to start from an understanding of how they view, experience and engage with marine climate change issues in their own terms. Public campaigns on marine environmental issues, such as the UK's 'Fish Fight', suggest that there may be considerable latent interest in climate change impacts on marine environments, which communications could tap into.

Climate change mitigation
There was evidence that some UK and European citizens are taking steps to mitigate climate change in their own daily lives. However, a number of barriers were identified. The following reasons were all highlighted as disincentives to acting in an environmentally responsible manner and mitigating climate change:

1. the high costs of some environmentally beneficial behaviours
2. the lack of infrastructure to support environmentally sustainable behaviour
3. an absence of guidance and information other than very basic mitigation actions
4. perceived personal inefficacy
5. the perception of free riders.

Climate change adaptation

As for adaptation, it was seldom mentioned. In particular, there was little evidence that participants who lived in vulnerable coastal locations had given much thought to protect themselves against flood risk. The evidence suggests that they are indeed aware of the risks, but do not see themselves, or the actions they can take as individuals, as effective in dealing with them.

Impact and dissemination of results

The CLAMER website

The CLAMER website homepage (see http://www.clamer.eu online) shows a surrealistic image of divers in a red sea. The picture aims to grab the visitors’ attention and invite further discovery of the information offered by the buttons randomly placed across the image. More general and practical information about the project can be found in the header tabs. The broad concept of the CLAMER website is to become a portal for marine climate change science and outreach products generated through and brought together by CLAMER partners.

In order to engage a wider audience events were organised in collaboration with European aquaria and marine institutes. The course of these activities together with a video message contest could be followed not only on the website but also by a CLAMER group on the social medium 'Facebook'.

The CLAMER fact sheets

In order to distil some of the key messages out of the CLAMER Synthesis of European Research on the effects of climate change on marine environments, five fact sheets were produced by the Marine Board-ESF. These attractive double-sided A4 glossy cards covered the following themes:

1. Marine eutrophication
2. Thermohaline
3. Circulation changes
4. Temperature changes
5. Sea level change
6. Ocean deoxygenation
7. Coastal hypoxia

Aimed at decision and policy-makers, but also accessible to the general public, these CLAMER fact sheets highlight the main points of these important marine climate change areas, in a clear and concise manner. The fact sheets were distributed at the CLAMER conference and will be included in the CLAMER mailing package.

The CLAMER report card

The 16-page CLAMER report card, 'Sea Change' provides a brief overview of the opinions expressed by 10 000 European citizens on marine climate change risks and impacts. This survey was complemented by a participatory workshop, a review of relevant studies and a review of EU scientific outreach activities. Together, these provide unique and compelling insights into how citizens relate to marine climate change and how the EU can improve public engagement on these issues.

The Report Card is packaged in a colourful and concise format and aimed at the public and policy-makers. It was distributed at the project conference in September 2011. A further 600 copies have since been printed to be disseminated to CLAMER partner organisations for use as outreach material for meetings and conferences across Europe.

The CLAMER book

The CLAMER booklet aimed to summarise the main messages compiled within the CLAMER project for the general public, in an attractive and easily digestible format. Central to the book's distinction are the 12 striking images created by Glynn Gorick. Each of these works of art depicts a marine ecosystem theme affected by climate change, such as primary production or non-native species and accompanies a short chapter of the same topic.

The glossy A4 booklet was produced by the Sir Alister Hardy Foundation for Ocean Science, in collaboration with Glynn Gorick and includes an introduction on public attitudes and communication written by CLAMER members at the University of East Anglia and the Centre for Environment Fisheries and Aquaculture Science.

‘Climate change and European Marine Ecosystem Research’ was launched at the CLAMER conference pre-event in Brussels on 14 September 2011. The initial print-run of this colourful 53 page book was 1 000. In addition to being provided to all CLAMER conference participants, extra copies have been distributed to CLAMER project contributors for further dissemination. The potential production of the book on a commercial basis is currently being explored.

This CLAMER achievement is aimed to reach children and adults world-wide and provide an informative and educational experience surrounding the complex marine climate change issues of today and the future. Gorick's eye-catching images have already been further used by CLAMER (e.g. conference
promotion, website etc.) to stimulate engagement with the public, policy-makers and others in the
dissemination of the project's main messages.

The CLAMER film

During February 2011, documentary maker Jean-Yves Collet travelled to several coastal areas in France,
the Netherlands, Belgium, Germany, Italy and the United Kingdom. Along the way, he interviewed
scientists, professors, farmers, fishermen, students and the man on the street about their views on the
effects of climate change on marine environments in Europe. The storyline is further inspired by the results
from the CLAMER European survey on public perception and awareness.

With light humour and inspiring scenery, this 57 minute production by Com On Planet, touches upon the
differences between what is known about marine climate change in the world of research and how the
general public perceive the marine impacts and socioeconomic consequences of climate change. Issues
including sea level rise, changes in marine biodiversity, modifications of ocean currents and ocean
acidification are explored.

Local CLAMER events at marine institutes and aquaria and the video message contest

To engage with the public in a more active way, CLAMER decided to go to Europe. About 25 aquaria and
11 marine institutes from across Europe took up the CLAMER invitation to hold 'marine climate change
side-events'. According to the aquaria statistics up to 1.5 million visitors were received by the aquaria
hosting the events during June and July 2011.

All participants received a promotion package and were encouraged to organise dedicated events on
climate change and the marine environment. Along with a quiz, the promotion package contained a teaser
of the CLAMER documentary, an informative display in the local language with marine climate change
facts.

There was also an invitation for visitors to take part in a video message contest about their perception of
how climate change impacts his or her regional sea. This resulted in more than 40 clips sent in form seven
countries. The winning video, 'Surfing on climate change' by Jelmer Bot and Emile Druif, two students from
the public school 'De Hogeberg' on the island of Texel (The Netherlands) can be viewed at:
http://www.clamer.eu/component/photogallery/?album=2101&pic=41357

Evening lectures given by marine scientists for example at the Netherlands Institute for Sea Research, at
the University of Lecce (Italy) and during World Ocean day in Bruges (Belgium), reached hundreds of
people. An interactive event, linking fishermen and divers, was organised in Spain. School children could
participate in workshops at the University of the Algarve (Portugal). Citizens from Plymouth (UK), Azores
(Portugal) and Varna (Bulgaria) got in touch with sound science during open days at the universities or
institutes, etc.

During the course of the side-events, several aquaria and institutes were visited by a CLAMER team to
boost enthusiasm for the information campaign. This European tour could be followed by Facebook and
was documented with interviews taken at the aquaria and institutes.

Thanks to this broad voluntary network of institutes and aquaria CLAMER had the opportunity to communicate the existence of the project and its relevance for society. Special thanks go to the enthusiastic support of the European Union of Aquarium Curators for making this pan-European action such a success.

The international CLAMER conference

The international CLAMER conference 'Living with a warming ocean: European research and public perception of climate change impacts in the marine environment' took place at the Royal Flemish Academy of Belgium for Science and the Arts in Brussels on 15 September 2011, with a pre-event on the evening of 14 September.

At the pre-event the CLAMER booklet was officially unveiled, a presentation for a wider audience on climate change impacts on the marine environment with Iceland as a case study was delivered and the CLAMER documentary, 'Living with a warming ocean' was premiered.

The conference was chaired by Quentin Cooper, presenter of 'The Material World' on British Broadcasting Corporation (BBC) Radio 4, the UK's most-listened-to science programme. During the conference the key findings of the CLAMER project were presented by CLAMER partners, including the results of the pan-European public poll; the main messages from the state-of-the-art overview of EU research results on marine climate change and the outcomes of the dissemination activities of the project.

Leading experts in climate change science and related mitigation and adaptation strategies addressed the audience, among them Dr Rajendra Kumar Pachauri, Chairman of the Intergovernmental Panel on Climate Change (IPCC), Prof. Jean-Pascal van Ypersele (vice-chair) and Ms. Manuela Soares - Director Environment, DG Research and Innovation.

The afternoon session started with introductory key-note presentations by Dr Sybille van den Hove (MEDIAN) who focussed on linking marine and climate change research with policy and by Quentin Cooper (science journalist for BBC radio) who explained how to engage the wider public with climate change research.

Parallel working sessions followed, allowing participants to discuss three themes. The day was closed with a plenary discussion and a summary of the most important results from the three workshop topics:

1. climate change impacts and European marine policies
2. science and public awareness: How can the outputs of marine climate change research be better communicated and valorised to the public?
3. organisation of the European marine climate research community and agendas in the future.

The pre-event was attended by 97 persons and 143 persons participated at the conference, among them scientists, policy-makers, key representatives of civil society, industry, NGOs and aquaria, science
communicators, press and His Royal Highness (H.R.H.) Prince Laurent of Belgium.

The participants received a conference folder with various CLAMER outreach products including: the book of conference abstracts, the CLAMER synthesis report, the CLAMER booklet, a 2012 calendar with artwork by Glynn Gorick, International Innovation article, fact sheets derived from the CLAMER synthesis report, the report card of public perception and awareness and a DVD of the CLAMER documentary.

The outcomes of the conference have been made available on the CLAMER website where videos of the presentations, the book of conference abstracts and conference photographs are available for viewing. A conference report currently under preparation will serve as a written record of the work that was presented and of the outcomes of the workshops. It will include a preface by the project coordinators, extended abstracts written by the speakers and a summary of the conference workshops. The 35 page publication will be illustrated with conference pictures and will be distributed to all conference participants in December 2011. It will also be available for download from the CLAMER website.

CLAMER press releases and media coverage

During the course of the project three press releases were produced by Terry Collins & Associates in cooperation with researchers linked to CLAMER. Terry Collins & Associates is a Toronto-based firm specialised in publicising science, environment and health-related research. Each press release touched on various findings of the CLAMER project but was focussed on a central theme:

1. April 2011: 'Icy meltwater pooling in Arctic ocean: a wild card in climate change scenarios' - focussed on physical ocean changes.
2. June 2011: 'Prodigal plankton species makes first known migration from Pacific to Atlantic via pole' - tackled the biological changes due to a changing climate.
3. September 2011: 'EU research synthesis warns major threats loom due to changing oceans, sea levels, erosion top public concerns' - launched in the run-up to the CLAMER conference, revealed the outcomes of the European poll on public perception and knowledge of marine climate change.

All news releases received extensive media coverage, being picked up by leading newswires, radio stations and published in dozens of magazines and newspapers, including The Times, The Independent, The Sunday Telegraph, El Mundo, Aftonbladet, The Irish Examiner etc. The press coverage was not restricted to Europe but reached a worldwide network, including hundreds of online stories. Translating the scientist's balanced message into a striking press story was not an easy task, but the CLAMER press-releases succeeded in putting European marine research in the picture on three separate occasions.

In addition, an article about the CLAMER project, 'Testing the waters' appeared in the Environment issue of the International Innovation magazine (May 2011), together with an interview with project coordinator Carlo Heip, entitled 'Water on the brain'. The issue has been distributed to approximately 35,000 European environment and climate stakeholders.

Peer-reviewed publications
In preparation

To date, one scientific article that was supported by CLAMER has been published (Philippart et al., 2011). In October 2011, it was the most electronically downloaded article from the Journal of Experimental Marine Biology and Ecology. Two further manuscripts currently in preparation under the following working titles are expected to be completed for submission to academic journals in January 2012:

1. In search of relevant scales for adaptation to climate change
2. Public engagement with marine climate change impacts.

Published abstract


The Northern Hemisphere has been warmer since 1980 than at any other time during the last 2 000 years. The observed increase in temperature has been generally higher in northern than in southern European seas and higher in enclosed than in open seas. Although European marine ecosystems are influenced by many other factors, such as nutrient enrichment and overfishing, every region has shown at least some changes that were most likely attributable to recent climate change. It is expected that within open systems there will generally be (further) northward movement of species, leading to a switch from polar to more temperate species in the northern seas such as the Arctic, Barents Sea and the Nordic Seas and subtropical species moving northward to temperate regions such as the Iberian upwelling margin. For seas that are highly influenced by river runoff, such as the Baltic Sea, an increase in freshwater due to enhanced rainfall will lead to a shift from marine to more brackish and even freshwater species. If semi-enclosed systems such as the Mediterranean and the Black Sea lose their endemic species, the associated niches will probably be filled by species originating from adjacent waters and, possibly, with species transported from one region to another via ballast water and the Suez Canal. A better understanding of potential climate change impacts (scenarios) at both regional and local levels, the development of improved methods to quantify the uncertainty of climate change projections, the construction of usable climate change indicators and an improvement of the interface between science and policy formulation in terms of risk assessment will be essential to formulate and inform better adaptive strategies to address the inevitable consequences of climate change.

Closing with a clamour

In December 2011, a targeted mailing consisting of CLAMER publications, including the synthesis report, the 35 page conference summary report and the report card on public perception and awareness will be distributed. This package will be sent to a select group of contacts including Members of the European Parliament, selected EC Officers, European and international marine organisations and agencies, as well as other high-level project partner contacts.
As a final CLAMER dissemination action, a closing email will be circulated to a broad contact group. This will aim to draw attention to all the CLAMER achievements and the reports available on the CLAMER website.

Finally, members from the project's participating institutes will continue to spread the word in presentations and wider networking, as well as personally distributing copies of the CLAMER deliverables.

Project website: http://www.clamer.eu

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