PROCEEDINGS

International CLAMER Conference
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LIVING WITH A WARMING OCEAN:

European Research and Public Perception of Climate Change Impacts in the Marine Environment

VLIZ SPECIAL PUBLICATION 53
Jan Mees, Jan Seys, Thalia Watmough & Karen Rappé (Eds.)

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Royal Flemish Academy of Belgium for Science and the Arts

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Preface by the project coordinators

The international conference 'Living with a Warming Ocean' brought the 18 month European Seventh Framework Programme project, CLAMER to a close. It was our pleasure to welcome to this event: the CLAMER consortium, the invited speakers - Ms. Manuela Soares, Prof. Jean-Pascal van Ypersele, Dr. Sybille van den Hove and Mr. Quentin Cooper - and the participants, among them H.R.H. Prince Laurent of Belgium.

In recent decades, a vast amount of diverse evidence has accumulated to scientifically support the conclusion that climate change is impacting our marine ecosystems as much as those on land. The European Commission has been an integral international sponsor of climate research through its various Framework Programmes, and the European marine science community, in particular, has contributed significantly both to this new knowledge and the discussions on climate change.

For the first time, these research efforts and findings have now been summarised in the CLAMER Synthesis Report. This state of the art overview includes physical changes such as sea-level change, sea temperature increase and stratification, throughout the European marine regions. It also shows changes in abundance and distribution of marine organisms. Despite these advances, observations from the oceans and seas are scattered and a number of scientific unknowns remain. Better and more systematic observations are required to get to grips with the high variability in many data in order to extract trends more reliably and provide more adequate support in drawing-up effective policies.

The areas where information is lacking have also been addressed in the CLAMER Synthesis Report, both by research theme and regionally by European basin. This report thereby underlines the research to be prioritised in the future; finding solutions to address these issues in an efficient and collaborative manner will be paramount. We therefore welcome the European Commission's commitment to continue its support to research and innovation, and ultimately to EU policy objectives, through 'Horizon 2020 - the Framework Programme for Research and Innovation', which will be introduced after 2013.

Besides a need for continuous marine research, it is also essential that well-functioning interfaces allow for two-way flows of knowledge between the worlds of research and policy. Such interfaces are a necessary ingredient for (more) effective governance of complex issues.

In terms of addressing a wider audience, at best assumed to be concerned about the oceans, CLAMER also set out to uncover how much of this scientific information is actually reaching the public. The CLAMER poll conducted across 10 European nations assessed the public knowledge and opinions on marine climate change issues. It reveals that the public clearly cares about climate change, ranking it second overall from a list of major global issues (only poverty scored higher) and almost everybody polled believes that climate change is at least partly caused by humans. Fundamental messages are getting through to the public (sea level rise and temperature change), but for some issues, most notably ocean acidification, public awareness is extremely low. In a further outreach study, CLAMER partners have highlighted that in order to catch the interest of a wider audience, scientific information needs to be presented in such a way as to create engagement and to interact with the public on their own terms, rather than merely to 'increase public knowledge'. In addition, the diversity among the public needs to be acknowledged, and communications should be adapted and targeted accordingly.

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

Finally, we hope this project succeeded in making such a clamour* that everyone will respond by addressing and communicating marine climate change issues in a resourceful and collective fashion.

Carlo Heip & Katja Philippart

**The pronunciation of the acronym of the project 'CLAMER' and the word 'clamour' sounds similar. As a mere coincidence this gives a double meaning to the acronym as the word 'clamour' stands for making a loud noise, as from a large number of people / making a public demand / a vehement expression of a collective feeling.*

Pre-event – 14 September 2011

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Iceland – a land of fire, ice and climate change

Iceland, remote but not untouched

Climate change is a global phenomenon that affects local marine ecosystems via a cascading range of physical, chemical and biological processes acting at different scales. Even the most remote areas of the world do not escape the consequences of climate change such as a rise in carbon dioxide concentrations, a rise in temperatures, shifts in fish stocks and declines in recruitment success of seabirds.

Iceland, for example, is a relatively small island in the midst of a large ocean and one of the world's smallest polluters (Fig. 1). Although the emission of CO_2 per km^2 of Iceland is only 6 % of that of the United States, the average concentrations of CO_2 at this location do not differ from those measured at other locations around the world (Fig. 1).

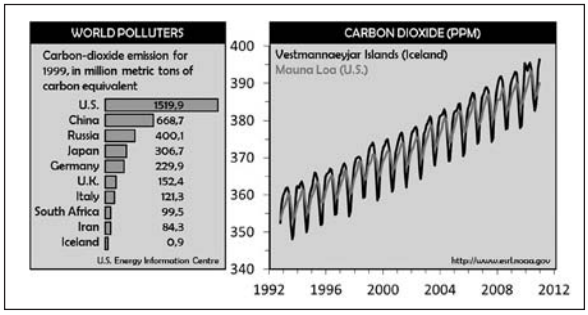

Fig. 1. Carbon dioxide emissions (10^6 metric tons C equivalent) per country in 1999 (left panel) and carbon dioxide concentrations as measured in the US (grey line) and at Iceland (black line) from 1992 to 2011 (data derived from cdiac.ornl.gov).

Global changes with local impacts

The global change in air temperatures was strongly felt in Iceland. Whilst the average global temperature increased approximately 0.8˚C between 1850 and 2010 (cdiac.ornl.gov), the air temperature as measured in the west part of Iceland increased approximately 3˚C during this period (www.vedur.is; Wood *et al.*, 2010). This increase in temperature coincided with many changes in the local terrestrial and marine environment which are considered to be at least partly caused by global climate change.

Iceland is a glaciated country, with approximately 11 % of its total area covered by glaciers. Between 1958 and 2000, the area of the Icelandic ice caps declined from 11670 km^2 to 10983 km^2 (notendur.hi.is). This decline appears to be mainly caused by the increase in temperature as there were no long term variations in precipitation during this period. If the present trend continues, most glaciers on Iceland will have melted away within the next 500 years.

Since 2004, Iceland has also experienced widespread breeding failures in colonies of several seabird species, including the black-legged kittiwake, Arctic tern, black-headed gull, Brünnich's guillemot, and Arctic skua (Nordic Council of Ministers, 2010) which is considered to be at least partly linked to global warming. The negative correlation between sea temperatures and the breeding success of seabirds is considered to be caused by declines in availability and quality of their prey, but underlying mechanisms are still to be discussed (Fig. 2).

For example, the climate-related part of the decline in seabirds might be the result of direct bottom-up regulation, i.e. a decline in birds due to decline in fish due to warming-induced decline in zooplankton. The causes might, however, also be much more complex, e.g. involving climate-induced shifts in interactions with other predators such as Atlantic mackerel and other prey species such as snake pipefish (Harris *et al.*, 2008; Nordic Council of Ministers, 2010; K. Lilliendahl, pers. comm., 2011).

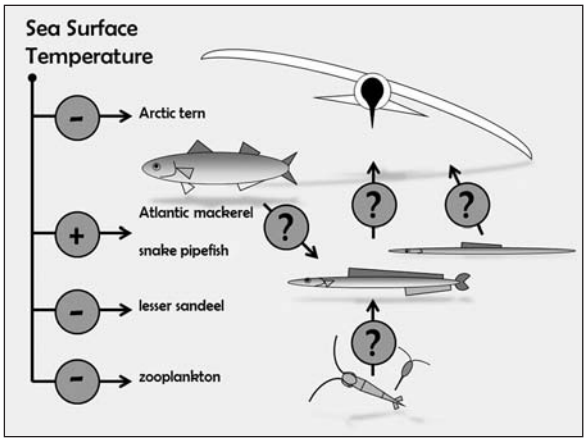

Fig. 2. Conceptual model on the possible direct and indirect relationship between an increase in sea surface temperature (SST) and the observed decline in seabirds, such as the Arctic tern, in the waters surrounding Iceland (based upon Harris *et al.*, 2008; Nordic Council of Ministers, 2010; K. Lilliendahl, pers. comm., 2011).

Local changes with global impacts

These environmental changes at Iceland as the result of global climate change may be backfiring to the rest of the world. The melting of ice caps covering Icelandic volcanoes may enhance the probability of volcanic eruption with tephra hazards (Fig. 3), of which the impacts can be felt at a large distances. In 2010, for example, the ash cloud produced by the volcano under the glacier Eyjafjallajökull forced a temporary closure of north-western European airspace, costing the aviation industry an estimated $250 million per day (Gudmundsson *et al.*, 2010).

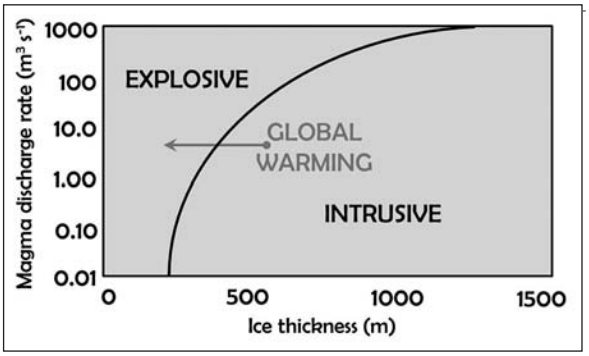

Fig. 3. Modelled relationship between ice thickness and magma discharge rate. Explosive eruptions (above the line) are favoured by thin ice and high magma discharge rates. They are more hazardous than intrusion eruptions since meltwater is produced far more quickly and eruptions may pierce the ice surface, producing tephra hazards. Modified from Tuffen *et al.* (2010).

Such eruptions may have had impacts on marine ecosystems as well. The supply of the iron-rich volcanic ash by Eyjafjallajökull to the Atlantic Ocean may have lengthened the spring bloom of phytoplankton in the sub-polar regions of the North Atlantic (E. Achterberg, pers. comm., 2011). Volcanic ash clouds may contain sulphur dioxide, such as has been observed during the eruptions of the Icelandic Mount Hekla in 1980 (Carn *et al.*, 2008). The subsequent increase of the acidity of the ocean's surface may result in malformation and enhanced dissolution of calcifying organisms (Wall-Palmer *et al.*, 2011). The subsequent decline in functioning and abundance of calcifying organisms may affect marine ecosystem services, including the sequestering of CO_2 by marine phytoplankton.

Scales matter

Summarized, recent developments at Iceland illustrate that global climate change affects local ecosystems which can have consequences for large-scale biodiversity and ecosystem functioning again. These interactions between developments at different scales stresses that climate change science requires the identification of the dominant processes across all scales in time and space. Such information is needed in order to further understand and predict the inevitable impacts of climate change on our environment and to develop truly integrated and complete adaptation responses.

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The CLAMER film: 'Living with a warming ocean'

From the start, the working title of the film project underlined the challenge of creating a film for a wider audience addressing this topic: *'Production of a film on climate change in European marine waters and its socio-economic consequences, including documentation of public knowledge on the issue'.* The film title quickly rendered to a catchier one *'Living with a warming ocean'* and a good balance was sought between highlighting science, socio-economic consequences and public knowledge to make the documentary interesting for the general public.

An equilibrium between the conceptual and the factual aspects of a documentary had therefore to be found: 'conceptual' being the expression of intellectual ideas and theories, expressed in the narration or by means of interview; 'factual' being sequences which show actual human experiences. This was achieved by approaching the subject from the public point of view, zooming in on science communication towards the general public and adding interviews with scientists; a combination of sequences that distinguishes this documentary from other climate change documentaries.

Scientists, farmers, fishermen, students and the man on the street were asked about their views on the effects of climate change on marine environments in Europe. The storyline touches upon the gap between what is known by research and how the general public perceive the marine impacts and the socio-economic consequences of climate change. Issues including sea level rise, changes in marine biodiversity, modifications of ocean currents and ocean acidification are explored. Filmed in seven European countries, from Greece to northern Germany via Italy, France, Belgium, the Netherlands and the United Kingdom, a broad range of opinions demonstrate the involvement of all levels of society to marine climate change. The storyline, although created before the results of the European poll on public knowledge and perception were available, concurs well with the outcomes of the poll. This proves the reliability of these results, nicely illustrated, for example, by the match in the Dutch people's perception of rising sea levels.

The 57 minutes long documentary is available to view and for download at the CLAMER website. Further opportunities for commercial televised release of the film are being explored.

Conference – 15 September 2011

SESSION 1

European marine climate change research in a global perspective

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Overview of European research on climate and marine environment

There is growing recognition that Europe's - and indeed the world's - future economic and physical well-being remain closely linked to its oceans and seas, and to the preservation of this environment from the impacts of climate change.
First of all, the oceans are responsible for hydrologic cycles and also play a significant role in regulating global and regional climate and moderating weather systems around the world.
Secondly, key economic sectors, such as fisheries, aquaculture, coastal tourism, and marine infrastructures (such as ports and shipping) depend on the good status of the marine environment.
In this perspective, marine science and technology have a crucial role in improving the understanding of marine ecosystems and in providing the basis for the sustainable management of the marine environment.

European climate research addresses key questions on the functioning of the Earth-system, the human interference, its impacts and consequences, and it also promotes technological improvement, innovative management practises (e.g. related to adaptation and mitigation strategies), new business models and services, and behavioural changes. Research aims to quantify not only global but also local impacts of climate change in the most sensitive regions of Europe and worldwide, and it supports further policy options.
Specifically, research allows to enhance the knowledge on the many impacts of climate change on the marine environment (such as those due to sea level rise, coastal flooding, ocean acidification and its consequences on biodiversity and ocean ecosystems, decline in wetland areas, changes in ocean currents and ice cover, and salt water intrusion into agricultural soils) and their effects on economic and societal activities.

Since Framework Programme 5 and during Framework Programmes 6 and 7, the European Commission has been leading international efforts to investigate major processes of climate change and its impacts on our marine ecosystems. Research has been conducted in all European geographical areas, from the North Atlantic to the Mediterranean, and by an integrated approach that includes observation, monitoring, modelling, and management.
Among many initiatives launched under this framework, it is worth mentioning the 'Ocean of Tomorrow' joint calls carried out since 2009, which promote a cross-cutting and multidisciplinary approach to face this complex challenge, and aim at supporting specific policy needs.
In fact, in 2008, the European Union adopted the 'Marine Strategy Framework Directive', whose overall aim is to protect more effectively the marine environment across Europe. This Directive constitutes the vital environmental component of the Union's maritime policy, designed to tap on the full economic potential of oceans and seas in harmony with the marine environment.
This Directive, together with the associated 'Commission Decision on criteria and methodological standards on good environmental status of marine waters' adopted in 2010 are perhaps the most 'science-based' EU pieces of legislation, since it comprises specific references to research needs.

Several projects have been investigating major processes of climate change impacts on our marine ecosystems. Indeed, impacts on marine environment by climate change are recognized in the European Commission's White Paper on climate change adaptation and the accompanying document on water, coasts and marine issues. Moreover, adaptation measures are also explicitly included in the Floods Directive, as well as in the Integrated Maritime Policy, the Marine Strategy Framework Directive mentioned above, and in the reform of the Common Fisheries Policy.
Internationally, the considerable research outcomes of the varied range of European funded projects in the climate change area have contributed substantially to the IPCC activities, and they are expected to feed as well into the current preparation of the 5th Assessment Report.

The European Commission is committed to continue its support to research and innovation, and ultimately to EU ambitious policy objectives, through 'Horizon 2020 - the Framework Programme for Research and Innovation', which will be introduced after 2013 with

three main objectives.
The first objective is to raise the excellence of the research base, needed to generate a higher number of world class scientific breakthroughs. Strengthening Europe's science base and the European Research Area means, among others, reinforcing the role of the European Research Council; promoting planning, preparation and construction of large scale research infrastructures; and equipping the next generation of researchers with innovative skills.
The second objective is to boost competitiveness and promote innovation, by broadening support across the full innovation cycle (including proof of concept, testing, piloting and demonstration), by securing a strong position in key enabling technologies (such as ICT, nanotechnology, or advanced materials), and by strengthening industry participation (in particular of SMEs) and establishing formal public private partnerships.
The third objective is to tackle grand societal challenges, contributing to the EU's ambitious policy objectives in areas such as climate change and resource efficiency, by promoting the more direct involvement of citizens and civil society in the whole chain of research and innovation.
'Horizon 2020' will boost Europe's global competitiveness and help create the jobs and ideas of tomorrow. As a future step in the creation of the European Research Area, it will ensure that EU-funded projects better complement and exploit synergies with national activities.
Within this enormous research undertaking, it is envisaged that different aspects of marine environment research will be supported under the challenge of climate action and under other relevant challenges (e.g. food), in order to maintain the long-term agenda of research on the marine environment, and specifically on impacts by climate change.
At the same time, research will continue to support the dialogue among researchers, policy makers and European citizens, in order to attract greater interest and involvement of citizens and civil society.

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Climate change impacts on marine ecosystems in Europe

The marine environment of Europe is vast and extremely diverse. Europe is bordered by the Atlantic Ocean to the west, the Arctic Ocean to the north and the Mediterranean to the south. Europe has the largest coastline relative to its surface of all continents and its economy is highly dependent on the seas and oceans in sectors such as tourism, transport, fisheries, energy, and many more. Changing marine ecosystems have direct consequences for human use and society.

Climate change affects the oceans. There is a large body of evidence that shows that the rapidly and steadily increasing CO_2 concentrations in the atmosphere create a greenhouse effect that is reflected in rising atmospheric temperatures. The evidence for the oceans is weaker because little is known about the deep ocean waters. Satellite observations of sea surface temperature and over the last few years the Argo floats, have shown that at least the upper 2 km of the oceans have also warmed up and that especially in the Arctic Ocean the warming has been very large. The subtle consequences of a warming ocean are increased stratification, leading to diminishing productivity, and increased hypoxia in the deeper waters, leading to the oceans losing oxygen slowly but steadily, with devastating effects on the deeper water biota. A not so subtle effect is the melting of an ever increasing part of the Arctic ice cover in summer.

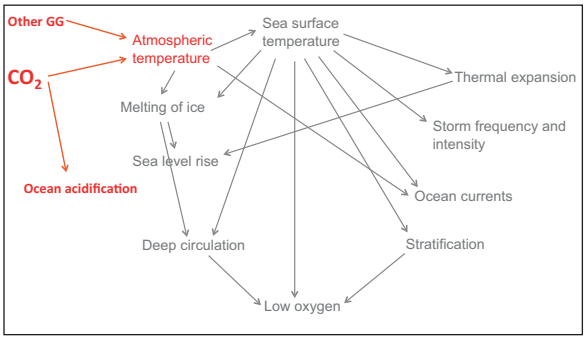

Fig. 1. Summary of physical and chemical effects of rising CO_2 (and other greenhouse gases).

The ecosystem effects of these changes are wide reaching. In response to warming waters, species are changing their distributions, in general moving poleward everywhere, from the North Sea to the Barents Sea, from the Med to the Black Sea and so on. There are now many well documented cases of northward shifting distributions in Europe and the Atlantic Ocean, including coastal species and commercial species. The Continuous Plankton Recorder data have well demonstrated this shift for open ocean plankton in the Northern Atlantic. Fishermen, seals and birds alike will have to follow the movements of their prey. The melting of ice in the Arctic Ocean is also changing the food web. Spectacular findings have been the recent presence of the diatom species *Neodenticula seminae* in the Western North Atlantic that had been extinct in the Atlantic for 800.000 years, and a sighting of a gray (also called grey) whale *Eschrichtius robustus* in Israel, a species that is extinct from the entire Atlantic since several hundred years and from the Eastern Atlantic since before the Middle Ages. Both the diatom and the whale have most probably migrated through the ice free Arctic from the Pacific to the Atlantic in summer.

In how far changing sea temperature will also increase the chances of new invading species or new pathogens from warmer waters to establish new populations is a matter of great uncertainty. One potential problem is the discovery that Vibrio's, including *Vibrio cholerae*, the agent that causes cholera, have become much more abundant in plankton samples over the recent two decades.

Increasing temperature also induces increasing stratification of the water column. Models with rising CO_2 indicate that upper ocean stratification and stability will increase and therefore mixing of the upper and deeper surface layers will decrease in the next fifty years with rising sea surface temperature. These conditions increase the dominance of picoplankton (= very small plankton) relative to diatoms and other microplankton. It is therefore reasonable to assume that NPP (Net Primary Production) by picoplankton will increase and NPP by larger microplankton will decrease, especially at low and mid-latitudes. This will lead to important changes in the food web and an overall lowering of productivity.

Increased stratification may also lead to oxygen loss in deeper waters. A slight but steady decrease of oxygen content has indeed been observed over the last fifty years in the open tropical Atlantic. Oxygen can only be introduced in sea water in the surface layer through exchange with the atmosphere and through photosynthesis. As solubility of gases is lower when temperature is higher, rising sea surface temperature may decrease oxygen content. Oxygen is consumed in the deeper waters through metabolism (including through nitrification, which is now known to be widespread). In a more stratified ocean deep water metabolism may be lower and this may counteract lower oxygen availability, but it will also lead to significant lowering of deep sea benthos biomass.

Another chemical effect of rising CO_2 is ocean acidification. Oceans are well buffered – and will not become acid but there is now sufficient evidence from open ocean measurements that the pH of the oceans is decreasing, with still largely unknown consequences. Experiments have shown that calcifying organisms such as corals and mollusks may suffer as a consequence, but how important the effect is in nature still has to be evaluated.

As the oceans are changing, also the human environment on land is affected. Increasing water temperatures change the atmospheric circulation and affect weather patterns on land. Melting of land ice and thermal expansion are raising sea-levels, threatening coastal habitats as the rate of melting and sea-level rise is increasing. The socio-economic consequences of climate change in the marine environment are potentially very high. Sea-level rise and coastal erosion require large investments and induce large costs in coastal protection, insurance, property loss and perhaps extensive moving of coastal populations. Changing weather patterns, possible increasing frequency of heavy storms will create damage to property and induce health risks. Tourism and maritime transport may in future concentrate in other geographic locations than today. The costs of changing ecosystems, biodiversity, fisheries and aquaculture are mostly unknown as are the costs of monitoring and research on consequences, but they are high. Fisheries and aquaculture will have to adapt to new fish stocks, new fishing methods, and new markets. Possible human health risks will require monitoring of pathogens. And so on, the list is long.

To summarize, we are observing many changes and much evidence is accumulating to scientifically support the conclusion that climate change is impacting our marine ecosystems as much as ecosystems on land. But observations from the oceans and seas are scattered and few sustained data series exist except for a few parameters. Even for temperature and salinity frequent systematic observation on a large scale is less than ten years old. A number of scientific unknowns remains and changes in vast areas in the deeper waters especially are a black knowledge hole. To come to grips with the high variability in many data in order to extract trends more reliably and support policies more adequately requires much better and more systematic observation.

The importance of the marine environment as a regulator of climate in Europe is not reflected at all in the scientific effort devoted to its study. As a demonstration, the most recent IPCC (Intergovernmental Panel on Climate Change) Fourth Assessment Report (2007) noted 28 586 significant biological changes in terrestrial systems but only 85 from marine and freshwater systems. On 15 September 2011 on the day of the CLAMER conference 84 723 scientific papers had been published that dealt with climate change, including only 6.624 scientific papers (7.8 %) on marine climate change. Less than 10 % of the scientific production thus deals with marine climate change, despite the fact that oceans represent 70 % of the surface and over 90 % of the volume of the biosphere of the planet and that oceans are crucial in understanding the impacts of climate change (weather, hydrological cycle, CO_2-sequestration, etc.)

In conclusion

- There is clear evidence of climate change impacts on the marine ecosystems around Europe.
- These impacts are different for different geographic areas and ecosystems.
- These impacts can therefore both increase or decrease the value of goods and services delivered by marine ecosystems.
- Economic risks and benefits therefore also differ according to different sectors (tourism, fisheries, coastal protection, offshore, maritime transport, etc.) and regions (e.g. south versus north, Atlantic versus Mediterranean).
- Ecological risks are multiple and connected and require efficient monitoring and evaluation in order to predict their consequences.
- The scientific effort to understand marine climate change is relatively low compared to other climate research and there is still a great need for sustained observation of climate change in the open and coastal ocean.

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IPCC, climate change research and the marine environment

Climate change due to human activities is happening now. The massive combustion of fossil fuels since the industrial revolution increased the atmospheric concentration of carbon dioxide, the main anthropogenic greenhouse gas, by 40 % between 1750 and 2010. The additional infrared heat trapping due to this change in atmospheric composition will continue to increase the average global surface air temperature and modify the Earth's climate. In its fourth Assessment Report (AR4, 2007), the Intergovernmental Panel on Climate Change (IPCC) Working Group I reports that in the absence of climate protection policies, continued emissions are likely to increase this global temperature by 1.6 to 6.9°C between the pre-industrial period and 2100, depending on which scenario and model is used. Such rates of global climate change are rapid and very unusual in the context of changes over the past two million years. Through thermal expansion and the melting of glaciers and ice sheets, this warming is causing sea level to increase, and ocean currents and even the thermohaline circulation will be influenced. The hydrological cycle will also be affected, with, e.g., significant drying of the average Mediterranean basin. Besides changes in the average climate, the probability of occurrence of heat waves (virtually certain), heavy precipitation events (very likely), intense tropical cyclones (likely), and extreme high sea level (likely) is due to increase in a warming climate.

IPCC Working Group II assessed the impacts that would accompany such warming. Some of them are specific to the oceans: e.g., coral bleaching would increase, and coastal regions would be subjected to increased damage from flood and storms. Ocean acidification due to the increased carbon dioxide flow to the oceans risks to further affect marine life.

The oceans will receive particular attention in the fifth Assessment Report (AR5) of the IPCC. For the first time, a specific chapter will be devoted to 'Open Oceans' in the Working Group II contribution. This talk reviewed those elements, and explained the role of the IPCC in assessing them so that all decision-makers have the best policy-relevant (but not policy-prescriptive) information at their disposal. Research on the marine environment will be key to provide improved knowledge to be assessed by IPCC.

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SESSION 2

The European public and its perception / awareness of climate change impact

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The outcomes of the first pan-European poll on public perception and awareness of climate change impacts on the marine environment

The FP7 EU project, CLAMER (Climate change and marine ecosystem research), builds upon a belief that there is a gap between what is known through research and what policy makers and the public know and understand about impacts of climate change in the oceans and seas around Europe. One of the key deliverables from the CLAMER project was a public polling survey, which aimed to find out what European citizens know and care about in relation to climate change impacts at the coast and in the sea.

Before embarking upon the polling exercise, CLAMER undertook a review of previous polling studies. This review revealed that whilst there was a growing body of work on public perception of climate change in general, there was very little in the way of work specifically on marine climate change. Furthermore, little attention had been given to public perceptions of marine environmental issues in general. The CLAMER polling exercise therefore provided a unique opportunity to start to redress this balance and not only look at how the public perceive marine climate change issues, but also to place these views in the context of public awareness and concern of marine environmental issues in general (pollution, overfishing, etc.).

Here we report on the key findings of the CLAMER public poll, the first of its kind to focus on the marine environment and climate change impacts. To get as broad a perspective as possible we cast the net widely, polling 10 000 people across 10 different countries, with coastlines spanning from the Arctic to the Mediterranean.

The CLAMER survey shows that the public still clearly cares about climate change, ranking it second overall from a list of major global issues (only poverty scored higher) and almost everybody we polled believes that climate change is at least partly caused by humans.

Interestingly, the survey results show that the marine issues the public are most concerned about are not directly related to climate change (pollution, over-fishing and habitat destruction), although a range of climate change issues (sea level and flooding, melting sea-ice, erosion and extreme weather) all score very highly. Of these issues, changes in extreme events are of the most immediate concern with over 50 % of people saying that this is already happening as a result of climate change.

The public appear to have a remarkably good understanding about the rate of sea level and temperature change, both over the past and coming century. This suggests some fundamental messages are getting through to the public. However for some issues, most notably ocean acidification, public awareness is extremely low. More effort needs to be made to highlight these issues using the most popular forms of media, TV and the internet. Ideally scientists, who have the highest levels of public trust, should be used to help communicate messages.

Personal action taken by European citizens to combat climate change tends to focus on mitigation measures (e.g. reducing energy use and using sustainable transport) rather than efforts to cope with climate change impacts by adapting, for instance by protecting their homes against flooding.

Support is highest for EU and national policy responses to make coastal and marine environments more resilient (e.g. through tightening controls on pollution). Mitigating climate change (e.g. through international agreements) is also seen as important. Adaptation measures were ranked lower.

Looking at marine climate change research themes that the EU should prioritise, there is a clear link between awareness and priorities, with melting sea ice coming out on top. However, some issues such as impacts on disease and pests and coastal communities are seen as being a high priority, despite limited awareness of these issues.

When the results are compared at a country level, or according to age and gender, there are some clear differences in opinions. For example, the EU is regarded as being 'effective on tackling climate change' by twice as many people in some countries than others, whilst females and older people are most 'concerned' about all of the issues raised. The EU needs to recognise these differences if it is to formulate effective communication strategies in the future.

The 'quantitative' approach taken in this polling exercise, looking at large numbers of respondents (some 10 000 in total) has been complemented by an in-depth workshop focussing on small groups of people in one geographic region, the UK (Terry & Chilvers, 2011). This workshop was used to explore the reasons behind some of the key messages emerging from the quantitative polling exercise.

The outputs from the poll have been further analysed as part of the CLAMER public perception summary report card (CLAMER, 2011). This incorporates the outputs from the face-to-face workshop (Terry & Chilvers, 2011) and the detailed reviews of past public perception work and EU scientific activities (Pinnegar & Buckley, 2011), to provide a widely accessible and compelling view of how European citizens relate to climate change issues at the coast and seas and what lessons the EU can learn to improve public engagement with marine climate science in the future.

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Exploring public understanding of, and responses to, marine climate change

Background

There has been a considerable attempt within the scientific community to understand natural and physical processes relating to climate change impacts on marine environments (CCIME). There is also increasing recognition of the need for mitigation and adaptation programmes and changes to individual behaviour regarding energy consumption, all of which depend on public engagement. The 'public', in this context, refers to individuals who do not have an expert scientific knowledge of CCIME. 'Engagement' refers to the personal connection that individuals make with an issue. It comprises understanding, perceptions based on views and attitudes, and behaviour. Attempts to engage the public depend on a sound understanding of how individual citizens connect with marine climate change.

Our two-part study

First we conducted a review of the academic literature on public engagement with CCIME, the first of its kind, and included literature on public engagement with climate change more broadly. The sources analysed belong to several distinct academic disciplines, in particular various branches of psychology and sociology. The findings of the review were then used to frame an in-depth qualitative study on the same topic that brought together members of the public and scientists in a participatory workshop in the United Kingdom in June 2011.

Our aim was to further existing knowledge of how publics understand, perceive, engage with and respond to CCIME, and the associated psychological and social factors. Adding to existing knowledge in this area is crucial to securing public support for climate mitigation policies and incentivising changes in individual behaviour designed to mitigate climate change, adapt to its impacts and support environmental resilience. Such knowledge can also provide a sound foundation for future communication and engagement initiatives. Our study has been informed by, and complements, the CLAMER project's European-wide public survey, as summarised in Buckley *et al*.'s (2011) 'Report on European public awareness and perception of marine climate change risks and impacts', and it subjects the survey findings to further interpretation.

Key findings of the literature review

It is well known that certain characteristics of climate change may discourage public engagement, for instance scientific uncertainty over its impacts, the wide diversity of interests and perspectives, and the fact that, for many people in industrialised countries, climate change seems a remote issue. Yet our literature review highlights a substantial research gap. 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 CCIME. 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 CCIME. The 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 links between knowledge of CCIME and engagement with them is contested; scientific information about CCIME 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.

The design of the qualitative study

Rather than comparing a review of the scientific evidence base with responses to a large-scale survey to gauge the knowledge 'gap' between scientists and the public, our qualitative study took the opposite approach. It sought to actively develop opportunities for interaction, challenge and debate between scientists (or

scientific information) and public participants in order to explore relations between and transformations in their respective knowledges, expertises and identities in greater depth. The design took the form of a workshop that brought together public participants and specialists on marine climate change issues in a day-long deliberative process. A hybrid methodology was used inspired by and drawing on several traditions, including focus group approaches, Deliberative Mapping, participatory rural appraisal (PRA) and participatory learning and action (PLA) techniques. In addition to exploring how such interaction may influence public understanding of marine science and climate change issues, the study enabled us to explore how scientists understand the public, and whether this understanding undergoes change during the process of their participation.

Key findings of the qualitative study

There are four broad areas where the qualitative study findings illuminate the public participants' understandings of climate change and marine environments. Firstly, there are the factors that underlie the salience of the issue for individuals, and their degree of concern. Secondly, the discussions throw light on the kind of knowledge individuals have about these issues, the way they frame them and their specific perspectives, which in some cases are very different from scientific perspectives. Third, individuals discussed the responsibilities of various actors, including themselves, to respond to CCIME, and their levels of trust in the different actors. Fourthly, reflections of both public participants and experts on their deliberations, their interactions with each other, and the opportunity to directly experience these issues through a beach walk, provide insights into the value of these processes and the extent to which they lead to transformations for the individuals involved.

The findings indicate that visibility and personal experience are important factors in both the salience of CCIME for individuals and their degree of concern. For some individuals, concern does seem to be driven by risk perception. Other individuals however see CCIME as a moral issue, because of their effects on vulnerable people and species; they engage with CCIME in a different way. Both the findings of this study and the literature review highlight the need to acknowledge such diversity among the public and target communications accordingly. The success of some recent public campaigns concerning the marine environment, such as the UK's 'Fish Fight', indicate that there may be considerable latent interest in CCIME, which communications could tap into; such interest is not necessarily based on perceptions of risk to humans. In addition, the qualitative study suggests that some members of the public have integrated and holistic views of marine climate impacts. These individuals tend to frame CCIME and climate change as aspects of the wider problem of humans' relationship with their environment rather than as discrete scientific issues. This further suggests that 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.
The high costs of some environmentally beneficial behaviour, the lack of infrastructure to support environmentally sustainable behaviour, an absence of guidance and information other than very basic mitigation actions, perceived personal inefficacy and the perception of free riders were all highlighted as disincentives to acting in an environmentally responsible manner and mitigating climate change. 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 protecting 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.

Participants' remarks about how the process had affected them reflect previous studies indicating that being able to take part in discussions and planning exercises related to climate change adaptation heightens individuals' engagement. As for the marine and climate change experts, they were surprised at the nature and level of knowledge demonstrated by the public participants, especially on the locally salient impacts of erosion and coastal flooding.

Both the literature review and the qualitative study have yielded valuable insights which could inform and strengthen future communications on, and public engagement with, CCIME.

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'Testing the water' – raising awareness of our changing seas

Raising awareness of our changing seas was one of the core activities in the CLAMER project. CLAMER set up an information campaign for the general public based on a website, a book, a documentary, a conference and media actions. To extend beyond this one-way imparting of knowledge, some other methods of communication have been applied and 'marine climate change side-events' were organised in order to engage European citizens.

Documentary 'Living with a warming ocean'

The documentary 'Living with a warming ocean' - produced by Jean-Yves Collet (Com On Planet) and Océanopolis (Brest) - shows the views of scientists, fishermen, farmers and the man on the street on the effects of climate change on marine environments in Europe. The storyline includes issues that people experience in their daily life, are worried about, and link with climate change. For example the impact of warming sea water and shifts in marine biodiversity on the daily life of fishermen or the impacts of sea level rise on farmers in the Netherlands. More difficult topics to communicate such as ocean acidification are also brought to the forefront. The documentary concurs with the outcomes of the poll on public perception and awareness and with the content of the CLAMER Synthesis Report. The documentary is available to view and for download at the CLAMER website. The 57 minutes long educational film is aimed at all public, stakeholders and decision-makers and it can be shown during public events, in academic courses and in public aquaria.

CLAMER booklet

The CLAMER Synthesis Report (Heip *et al*., 2011), one of the major outcomes of the project, summarizes European research results on the effects of climate change on marine environments and associated socio-economic consequences and targets scientists and policy makers. This scientific knowledge is translated to the public at large in the CLAMER booklet (Reid *et al*., 2011) produced by the Sir Alister Hardy Foundation for Ocean Science. The book highlights 12 key issues identified by scientists as being the current main research topics: temperature, sea-level and physical changes, primary production, micro-organisms, marine eutrophication, species composition shifts, jellyfish blooms, etc. Besides present knowledge, information is given on future projections and their confidence together with a key message. The different chapters are accompanied by wonderful artwork created by Glynn Gorick. The complex composite illustrations have a great educational value and assemble a lot of information. The book has been produced in a 1000 copies. The potential production of the book on a commercial basis is currently being explored.

Press releases & media coverage

During the course of the project press releases were produced by Terry Collins & Associates, a Toronto based press officer, in close cooperation with researchers linked to CLAMER. Translating the scientists' balanced message into a striking press story was not an easy task, but one with success. The press-releases succeeded in putting European marine research in the picture on three separate occasions:

- April 2011: 'Icy meltwater pooling in Arctic ocean: a wild card in climate change scenarios'
- June 2011: 'Prodigal plankton species makes first known migration from Pacific to Atlantic via pole'
- September 2011: 'EU research synthesis warns major threats loom due to changing oceans, sea levels, erosion top public concerns'

The press-releases received extensive media coverage, being picked up by newswires, radio stations, 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.
In addition, an article about the project CLAMER 'Testing the waters' together with an interview with project coordinator Carlo Heip 'Water on the brain'

appeared in the International Innovation Environment issue launched in May 2011. International Innovation has a readership of approximately 35 000 European stakeholders.

CLAMER website

The homepage of the CLAMER website 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 randomly placed buttons. In the header tabs more general and practical information about the project can be found. 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 the library, dedicated CLAMER publications can be consulted including the review paper, the CLAMER Synthesis Report, the science policy briefing sheets, the CLAMER booklet, the press releases, the book of abstracts of this conference, etc.
The portal offers under 'Expertise' an important catalogue containing information about nearly 100 European Union funded projects on marine climate change, starting from FP5. For the first time these projects are brought together and offered in an easy navigable database including project summary information and links to project websites.
The scientific information will be disclosed in the section 'Impacts'. Subtopics on climate change impacts on the marine environment will be posted and individual scientific publications will be translated into fact sheets; all easily comprehensible information targeting a wider audience.

CLAMER events at aquaria & marine institutes

To engage with the public in a more active way, CLAMER decided to go to Europe. European aquaria and marine institutes were invited to take part in 'marine climate change side-events'. Thanks to the support of the European Union of Aquarium Curators who made its members enthusiastic about this concept, about 25 aquaria, from west to east and from north to south Europe, engaged in the side-events, making it a pan-European action. On top of that, eleven marine institutes signed in.

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 and an informative display in the local language with marine climate change facts. 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. According to the aquaria statistics, up to 1.5 million people were received by aquaria hosting the events during June – July 2011.

There was also an invitation for visitors to take part in a video message contest. The content of the video had to reflect their perception of how climate change impacts his or her regional sea. The contest resulted in more than 40 clips sent in form seven countries. A selection was made by a CLAMER jury who choose as first prize winner the video 'Surfing on climate change' from Jelmer Bot and Emile Druif, two students from the public school 'De Hogeberg' in Texel - the Netherlands. 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.

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SESSION 3

How to shape future marine climate research and outreach in Europe

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Science for society: linking marine and climate change research with policy

We are currently confronted with a series of broad ranging environmental issues, including biodiversity loss and change, anthropogenic climate change, ocean acidification, chemical and radioactive contamination, stratospheric ozone depletion, and unsustainable use of freshwater. Many of these issues have reached a point where they are better characterised as 'crises', as we may be reaching critical points and end up operating outside a 'safe operating space for humanity with respect to the Earth system' (Rockström *et al.*, 2009).

Because environmental issues concern socio-ecological systems, that is, linked systems of people and nature[1], they are necessarily complex and characterised by properties of emergence, non-linear internal causalities, irreducible uncertainties, ignorance, indeterminacy and irreversibility (van den Hove, 2000; Stirling, 2010). Environmental issues are also characterised by interconnectedness, not only between environmental issues themselves but with societal and economic issues such as poverty, food security, population, health and well-being. The interconnections are between the systems, the risks, and the crises (EEA 2010; McGlade, 2009; Gee & van den Hove, 2010).

Knowledge and governance for complex and interconnected environmental issues

These characteristics of complexity and interconnectedness have implications in terms of knowledge and governance. The knowledge needed to understand environmental issues and support action is necessarily interdisciplinary and often transdisciplinary. It will always entail uncertainties and ignorance, it is in constant evolution, and it is plural and owned by a variety of knowledge-holders. As for the governance of environmental issues, it needs to operate on an evolving knowledge basis, hence be open to redefinition of issues (and options) as knowledge, societal priorities and technologies evolve. It must embrace complexity, risk, uncertainty, indeterminacy, ambiguity and ignorance. It must also reach across many policy sectors and calls for flexibility, cooperation, cross-fertilisation, joint-learning, and sharing of best practices across issues, sectors and scales. In other words environmental governance must be holistic and transformative.

High quality research is necessary to support environmental decision making, yet it is not sufficient. There is a need for well-functioning interfaces between science and policy which allow for two-way flows of knowledge between the research and the policy worlds.

Science-policy interfaces for environmental governance

As science and policy are and have always been intersecting domains of human activity, one can conceive science-policy interfaces as the processes that are implemented (spontaneously or not) to manage the intersection. As such science-policy interfaces can be defined as social processes which encompass relations between scientists and other actors in the policy process and which allow for exchanges, co-evolution, and joint construction of knowledge with the aim of enriching decision-making and/or research (van den Hove, 2007).

Well-functioning science-policy interfaces are a necessary ingredient of (more) effective governance of complex issues. Yet they are not a sufficient condition as the existence of strong political will and institutions is also of crucial importance and is affected by other factors than knowledge.

Science-policy interfaces can have many functions. They can allow for exchange and co-evolution of scientific and policy knowledge. They can facilitate timely translation of research into policy option or advice and early use of results in practice. They can facilitate or produce integrated assessments and demand-driven targeted assessments, including foresights and scenarios. They can be processes by which advice is provided either at the initiative of scientists or other knowledge holders, or as an answer to a request from decision-makers. They can also alert decision-makers about emerging issues, and/or contribute new thinking to address complex problems. They can contribute to the scientific quality process by allowing critical assess-

[1]*See Resilience Dictionary of the Stockholm Resilience Centre at: http://www.stockholmresilience.org (accessed October 2011).*

ment of scientific outputs in light of users' needs and of other types of knowledge. They can contribute to strategic orientation of research and appropriate funding of research in support of policies. Finally they can raise public awareness, as well as willingness to act amongst the public and stakeholders. Interfaces between science and society are equally crucial, as stressed by Quentin Cooper in his presentations.

Linking marine and climate change research with policy

Because of their potential serious impacts on ecosystems, societies and economies, climate change in the marine environment and ocean acidification have to be taken into account in, and across, a whole array of policy fields: environment, climate, energy, tourism, fisheries, infrastructures, transport, industry, etc. So here also high quality research and well-functioning interfaces between science and policy are needed. Because of its cultural, social, ecological and economic dependency on the marine environment and its ambitious marine and maritime policies, research on marine ecosystems and climate change is strategically important for Europe and a reflection is needed on how to better interface climate and marine research with marine and maritime policies.

Critical times

The future European research, development and innovation policy is currently being defined at the political level. Environmental research, including climate and marine ecosystems research, is at risk because of the dominance in today's political discourses and policy proposals of a narrow concept of innovation as a way to bring more products to markets and deliver economic growth in the short term. This is to be contrasted to a vision focusing on higher societal goals such as human health, wellbeing and quality of life, and on embarking on a more ecologically, socially and economically sustainable path. The latter vision calls for re-balancing market-focused innovation and socially meaningful and responsible innovation and to focus on innovation with a human purpose (van den Hove *et al*. 2011a).

Environmental research is a driver of socially meaningful innovation in all its forms for a series of reasons. Firstly, because of the interconnectedness of the various environmental and societal crises, in particular the financial/economic, the climate/energy and the biodiversity/ecosystems crises. Secondly, because environmental research can contribute to new and socially meaningful ways of transforming the socio-ecological system in which we live. Thirdly, because such research can contribute to the development of innovative epistemologies and methodologies applicable to other areas. And finally, because it is upstream of many technological innovations (e.g. biomimicry, blue biotechnologies, green technologies) (van den Hove *et al*. 2011a, 2011b).

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All aboard: getting climate change research to chime with the wider public

There is a need to bridge between research and the public and that is exactly what I'm trying to do as science journalist and with my involvement in Cape Farewell. As presenter of the BBC radio science programme 'The Material World', broadcast 52 weeks a year, I cover a broad number of subjects across science. Among them, climate change and marine climate change are featured regularly. In Cape Farewell, an organization which brings up the urgency of the global climate challenge, we are using some other communication routes to interest and excite people who would not respond in conventional ways.

In general there is room for much improvement in how the media communicates. The media often try to get the people's attention by alarming them (e.g. a story in the British media 'Oceans on a brink of catastrophe'). Stories have to look big, spectacular, making people feel worried or just the contrary, making them feel comfortable. For every positive article a reader gets a negative one. There is a big market in frightening people but there is also a big market in reassuring people. Much of the media end up confusing people – and there are examples of diametrically opposed views in the same newspaper on the same day. A role of the journalists should be to engage people by making the story personal.

Although the majority of the public accepts right now that it is time to act, their problem is not knowing how to act. All sorts of books, websites, programmes and articles give loads of practical advice, people don't always know which is best or most practical and ultimately many end up doing nothing: options paralysis.

Other ways to communicate and to engage people should therefore be applied. Some successful examples are science cafés to get people meeting scientists, dance projects, puppet plays, agitprop actions, architecture-art, using the value of celebrities, etc. There is no one best way – just as there is no single solution to climate change.

An organization launched to instigate a cultural response to climate change is Cape Farewell. Cape Farewell was set up by a group of artists who are certain that climate change is happening and who wonder what they can do to change people's views. The organization has a programme of activities that brings together marine scientists, leading artists, writers and educators stimulating interconnected activities designed to inspire artists and engage audiences with the social and environmental challenges of climate change.

One of those activities was a sailing expedition to Svalbard in 2010 to engage with marine scientific research being conducted on board the vessel Noorderlicht. The interaction between marine scientists and the artists - writers, musicians, visual artists, architects, directors - during this voyage resulted in art: the creation of an ice lens to burn paper, artwork based on polar bears affected by PCB (polychlorinated biphenyl) contamination, an island - appeared after receding of the glacier - claimed by an artist, etc. These stories appeared in the media, gave rise to debates on television and radio, and were even picked up through the Norwegian parliament. The expedition resulted in having art to engage people differently.

Another voyage was the one to Disko Bay - Greenland where well known musicians and others managed to involve young people by blogging, broadcasting text, images and videos about their expedition. These interesting interactions where artists respond to scientists actually affected the scientists' profile on the web in term of the numbers of people going to the website and to read the science. Inspired by this voyage the creative team responded to climate change not only in the Arctic but also on their return with exhibitions in cities, student conferences, documentaries on BBC television and radio, a Cape Farewell book, music albums based on the voyage, a novel and a film. Even the curriculum for schoolchildren of the UK included several elements based on the voyage. The overall idea of Cape Farewell is that for lots of different publics, there are lots of different ways of going out there. Any piece of work with a bit of thought can be done in this way.

So for example there is a video ‘Proper Education’, a remix by the DJ and producer Eric Prydz derived from the original Pink Floyd’s song ‘Another Brick in the Wall (part II)’ and made in partnership with the Global Cool foundation, an innovative climate change charity. The video, with a deep green message, made it to number two in the UK Singles Chart in 2007. Nothing in the lyric of the song is shown in the video. Set in a London estate, it shows a gang of young people breaking into local flats, in order to switch appliances off standby, change light bulbs for energy efficient alternatives and place bricks in toilet cisterns. The video ends with the words ‘You don’t need an education to save the planet’. Thanks to this video, the issues surrounding global warming were reaching a completely different audience.

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Workshop

Climate change impacts and European marine policies

Moderators: Jan-Bart Calewaert, Niall McDonough, Sybille van den Hove
Rapporteurs: Dina Eparkhina, Maud Evrard, Karen Rappé

The workshops addressed the question:
How can scientific knowledge be better translated and used in guiding effective policy decisions?

Generic conclusions and recommendations

1. Both scientists and policy makers need to be more pro-active in their approach by reaching out and asking the right questions:

    a. Policy makers need to ask more 'What if' questions. They need to engage with scientists and make it clear what information they need to help them make effective policy decisions.

    b. Scientists need to actively highlight emerging issues that may become increasingly important and require a policy response, but which policy makers and civil society in general may not be yet aware of.

2. The science community needs to be more sophisticated in its approach to translating the knowledge it generates through research, to information which is usable by policy makers and civil society at large:

    a. At the most basic (and passive) level, there needs to be an enormous improvement in the availability of reports and findings from research projects and programmes. The CLAMER project has shown that accessing this information in previous EU funded projects is very difficult.

    b. Scientists need to go further than that, however. Information should not just be made available passively but should be actively translated to a targeted audience. Different communication mechanisms and pathways may be used to address different sectors of society, which may accept and use information in different ways.

    c. Where scientists do not have the expertise in knowledge translation, they can and should work with expert translators who can undertake this role on their behalf.

    d. For translating scientific knowledge to policy makers it is important, where possible, to coordinate the knowledge translation with 'policy windows' as there are certain times when policy makers need, or are more ready to accept advice/knowledge.

    e. Where possible, translate the information actively through a direct interaction, i.e. make the interaction active rather than passive. This then results in 'active knowledge' which is more likely to be used.

    f. There is not just one science-policy interface but many which can operate at multiple levels in a nested system. More sophisticated awareness of the complexity of the science policy interfaces can enable better translation and potential for uptake of scientific knowledge.

3. It is important to continually evaluate the impacts of policy decisions. This allows continual improvement, particularly in the use of scientific knowledge through better engagement with scientists.

4. Policy decisions affecting use and management of marine environmental resources should follow an adaptive management approach whereby:

    a. Where there is sufficient knowledge: use an adaptive approach by proceeding with actions which are reversible;

    b. Where there is a complete lack of knowledge: use a precautionary approach. Avoid taking action until more knowledge is available;

    c. Where there is some knowledge (at a low level): engage in dialogue with stakeholders about the risks of action and follow an adaptive approach (if agreed), whilst ensuring the generation of better knowledge.

Recommendations specifically addressing marine climate change

5. Addressing climate change in the marine environment specifically, improving the science policy interface could benefit not just from *ad hoc* translation activities described above, but also from some improved 'targeted' transfer mechanisms. The IPCC Assessment Reports are a good example of a targeted assessment. However, these are global in scope and published at 4-5 year intervals. The majority of policy makers are making decisions which impact at local or regional level. Thus scientifically driven assessments, produced in a regular, straightforward and understandable format may be very valuable in translating information on potential climate change impacts at the appropriate spatial and temporal scales. The UK Marine Climate Change Impact Partnership (MCIP) Annual Report Card was proposed as a good example of a local targeted assessment which is generated by scientists and usable by policy makers.

6. Scientists need to improve on ways to communicate uncertainty of e.g. climate change impact predictions, without undermining the importance of the information. Communicating uncertainty and risk to policy makers and civil society is a challenge but can be done in a more positive way, rather than seeking too often to highlight, 'what we don't know'.

Understanding public understanding: the implications of CLAMER public perception findings for marine scientists and policy makers

Moderators: Jason Chilvers, Stefan Gelcich, John Pinnegar
Rapporteurs: Willem De Moor, Hans Pirlet, Wouter Rommens

The workshops addressed the theme:
How can scientific knowledge be better translated and used in guiding effective policy decisions?

Conclusions and recommendations

1. There are opposite opinions concerning what the role of scientists in public communication should be:

    a. Scientists should concentrate on science and communication specialists and science 'brokers' (e.g. aquaria) should take care of outreach aspects.

    b. Policy is changing and scientists have a responsibility to be more involved as individuals to spread core messages to the public. As scientists working at universities are a trusted source of information (Buckley *et al*., 2011), they should make more effort to disseminate their findings.

2. In terms of climate change the public is perceived as:

    a. Pessimistic as climate change is not seen as urgent or important by politicians.
    b. Interested and knowledgeable but wrapped up in their own lives and/or in denial.
    c. Feeling powerless and not knowing what they can do to help.
    d. Unwilling to act if they see others are not changing their behaviour.
    e. Only willing to make changes to their lives, if it is economically advantageous.
    f. Requiring incentives to take mitigation measures (e.g. education, tax breaks, subsidies).

3. Some tips for public engagement on scientific topics:

    a. Give the public the benefit of the doubt, they sometimes know more than scientists think and they ARE interested and curious to learn more. It is important to understand this and develop from their world views new messages related to global change.

    b. Define clear communication objectives and strategies to address target audiences, it is time consuming but more effective than blanket dissemination.

    c. Avoid attempting to explain all the details, concentrate on the main messages and make very clear cause–effect linkages.

    d. If alarming problems are presented, include a message about what the audience can do about it.

    e. Describe local issues to help people connect to the matter. It is important for the public to relate environmental problems to their day to day activities.

    f. Include economic and industry aspects, which the public can easily relate to.

    g. Beware of 'global warming climate fatigue': the press wants spectacular stories, scientists want to tell a balanced story. This can result in mixed messages and a passive attitude in audiences.

    h. Use more imaginative means of communication such as artists and art (e.g. as in the *Cape Farewell* project).

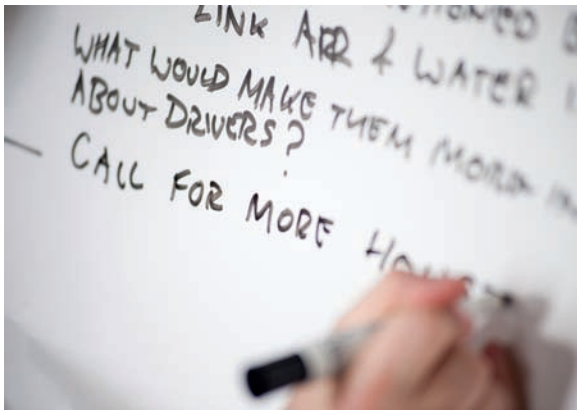
    i. Consider an interactive setting for dissemination such as aquaria and develop participatory events to get the public engaged.

    j. It is important to consider children (e.g. target schools). This is where a real difference can be made.

    k. Spread the word to the people who can spread the word themselves (e.g. teachers).

References

Buckley, P., J.K. Pinnegar, A. Dudek, and A. Arquati. 2011. Report on European public awareness and perception of marine climate change risks and impacts. Deliverable 2.2. Climate Change and Marine Ecosystem Research (CLAMER), 64 pp.



Organisation of the European marine climate research community and agendas in the future

Moderators: Carlo Heip, Jan Mees, Katja Philippart
Rapporteurs: Simon Claus, Thalia Watmough

The workshops addressed the theme:
Which problems and which questions on climate change impacts on marine systems should become the research priorities over the coming decade and what is required to realize these?

Conclusions and recommendations

1. Appropriate spatio-temporal scales, collaboration of research and improved data access:

    a. An integrated European funding and monitoring system is required, to maximise use of national/regional assets and avoid fragmentation.

    b. An increased number of and sustaining of basin-scale research programmes should be realised.

    c. Monitoring should occur for sufficient periods of time and new sustained long-term data series should be created.

    d. Efficient data exchange is required; e.g. common databases for biological data as well as physical.

    e. Scientific networking and increased collaboration is paramount.

2. An improved ensemble of climate models is needed which account for and/or require:

    a. A common scale between data and models, which requires rational networking of research communities.

    b. Downscaling from global to regional models and up-scaling of local observations.

    c. Improved reconstructions of palaeoclimate changes based on high resolution proxies at decadal time-scales.

    d. A database of climate reconstructions, accessible to modellers for comparison and validation.

3. Specific research is necessary to look into:

    a. What the now generally accepted to occur 2 °C increase will mean for the oceans.

    b. What the Greenland meltdown tipping point is.

    c. How primary production will change in the future (e.g. if/how fisheries will be affected etc.).

    d. Ocean acidification experimentation; shellfish industry links and the land-ocean interface (e.g. can the land alkalinity input stabilize coastal systems?).

    e. Modelling feedback of ecosystems and their biological components on climate change.

    f. Social impacts resulting from economic impacts to make messages more accessible to the public.

    g. More research effort into adaption to climate change and supporting decision-makers for mitigation.

4. There are opportunities for innovation and business related to marine and climate change research, such as:
    a. Innovation for human well-being.

    b. Marine renewable energy sources.

    c. Gas hydrate exploitation (also a risk with temperature increases).

    d. Carbon sequestration.

    e. Geo-engineering.

    f. Stopping technological innovations that are unnecessary.

    g. Transparency of business.

5. Regarding science-public communication:

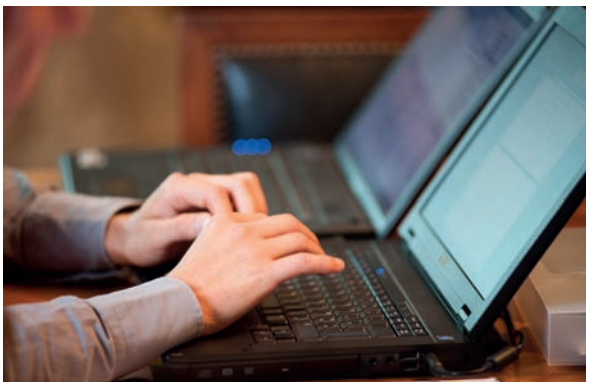
    a. It was generally agreed that an improved dialogue between science and the public is required, but some participants felt scientists should concentrate on science only.

    b. Formulation of specific messages by scientists will help successful information transfer.

    c. Training and investment in professionals (science communicators) is necessary to take care of science outreach.

    d. The amount of time and effort required by individual scientists to spend on outreach activities could be clarified at project/institute/national level.

    e. An ocean portal (e.g. 'Daily ocean report') could improve public interest and understanding in marine research.




BOOK
Jellyfish blooms and regime shifts
LIVING WITH A WARMING OCEAN:


www.clamer.eu


Jan MEES

CLAMER CONFERENCE

'Living with a warming ocean: European Research and Public Perception of Climate Change Impacts in the Marine Environment'

The CLAMER EU-FP7 project (www.clamer.eu) compiled scientific and public knowledge on the effects of climate change on the European seas and oceans. The conference presented key findings of the CLAMER project, including the results of a pan-European public poll on perception and awareness. In addition, the CLAMER documentary, 'Living with a warming ocean' was premiered at the pre-event of the conference.

Proceedings of the contact forum 'CLAMER conference. Living with a warming ocean: European Research and Public Perception of Climate Change Impacts in the Marine Environment' supported by the Royal Flemish Academy of Belgium for Science and the Arts.

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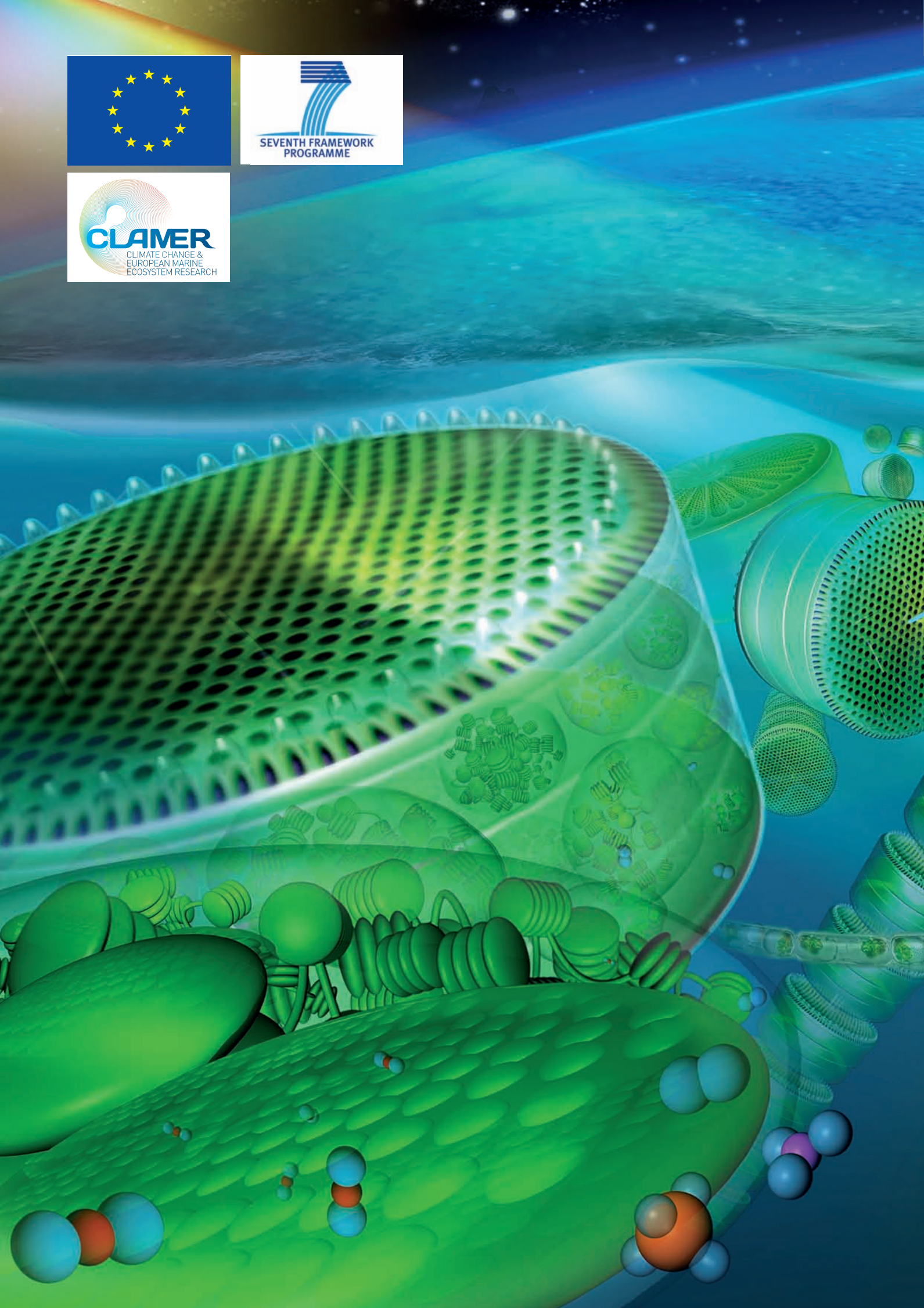
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