

# Mapping Coastal Risks in a Changing Climate

## A Training Pack





# **Mapping Coastal Evolution and Risks in a Changing Climate**

## **A Training Pack**

**Helen Fairbank & Jenny Jakeways  
Senior Coastal Scientist & Senior Coastal Geomorphologist  
Centre for the Coastal Environment  
Isle of Wight Council  
UK**

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The study was led by the Isle of Wight Council's Centre for the Coastal Environment in the UK and this publication draws upon its experience of coastal risk management, and that of its Project Partners gained over many years and specifically over the lifetime of this study.

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**Cover illustration:** *Pesaro Beach and Colle San Bartolo Natural Park,  
Regione Marche, Italy*

## CONTENTS

About the Project / Publication / Project Partners	Pages 1-3
Frequently Asked Questions: Where to Start?	Page 4
Executive Summary	Page 5

A Call for Action: Why is Climate Change a Problem for Coastal Regions?	Pages 6-7
Evolving Coastlines: Vulnerable Communities in a Changing Climate	Pages 8-9

How to Map Coastal Evolution and Risk: Selecting a Regional Study Area	Page 10
The RESPONSE Project Mapping Methodology: A Summary	Page 11
Map 1: Coastal Landforms and Coastal Processes	Pages 12-29
Map 2: Coastal Defence Management Types and Practices	
Map 3: Current and Historic Natural Hazards	
Map 4: Coastal Assets and Population	
Map 5: Coastal Behaviour Systems	
Map 6: Potential Coastal Hazards	
Map 7: Potential Coastal Risks	
Map 8: Summary of Potential Coastal Hazards	
Map 9: Planning Guidance	

Case Study: Central Southern England, UK	Pages 30-39
Case Study: Regione Marche, Italy	
Case Study: Languedoc-Roussillon, France	
Case Study: Aquitaine, France	
Case Study: North Yorkshire, UK	

Practical Application of the RESPONSE Methodology	Pages 40-41
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Resources provided on the accompanying CD-Rom and DVD	Pages 42-43
Identifying and Reducing Future Coastal Risk	Page 44
Conclusions and Recommendations	Page 45

## ABOUT THE RESPONSE PROJECT



'Response' (or 'Responding to the risks from climate change') is a three-year Project supported by the LIFE financial instrument of the European Community, launched in December 2006.



Nine Partner organisations in the United Kingdom, Italy, France and Poland have participated, led by the Isle of Wight Council's Centre for the Coastal Environment, UK.

The RESPONSE Project provides a framework for understanding and preparing for the impacts of climate change around the European coastline.

The aim of the Project is to assist organisations managing the coastline in assessing and prioritising the risks arising from climate change impacts on natural hazards, to inform the planning process. It will allow local and regional authorities and other coastal stakeholders to recognise areas of increasing risk due to climate change and to identify potential solutions.

The Project has demonstrated regional-scale mapping of coastal evolution and risks, taking account of the impacts of climate change. It has also examined the current and future costs of coastal natural hazards, to encourage cost-effective solutions.

Email: [response@iow.gov.uk](mailto:response@iow.gov.uk)

Website: [www.coastalwight.gov.uk/response](http://www.coastalwight.gov.uk/response)



## PROJECT PARTNERS

The Partners bring a wide range of experience of managing the impacts of natural hazards in the coastal zones of the UK, France, Italy and Poland:



- ▷ Centre for the Coastal Environment, Isle of Wight Council, UK
- ▷ IRPI Institute of Perugia, National Research Council (CNR), Italy
- ▷ Bureau de Recherches Géologiques et Minières, France
- ▷ Regione Marche, Autorità di Bacino Regionale, Italy
- ▷ Provincia di Macerata, Italy
- ▷ Provincia di Pesaro e Urbino, Italy
- ▷ Scarborough Borough Council, UK
- ▷ Maritime Office in Gdynia (Urząd Morski w Gdyni), Poland
- ▷ SCOPAC Regional Coastal Group, Central-southern coast of England, UK

## ABOUT THIS PUBLICATION

This 'Training Pack' on coastal evolution and risk mapping guides the reader through the process of producing maps that show the future pattern of coastal evolution and risks across a region (or sediment cell), which take account of the impacts of climate change. These maps can provide an understanding of the pattern and scale of coastal change and the future of natural coastal risks and hazards. The maps can be prepared and used by coastal managers, local/regional authority officers, engineers, practitioners and planners to contribute towards: the identification of future requirements for coastal protection measures; showing locations where managed retreat may be necessary; assessing potential areas suitable for coastal development and to assist emergency planning. The final maps in the sequence can also be used by decision-makers and politicians to understand and communicate the pattern and severity of current and future coastal risks, and assist in targeting resources effectively.

The Training Pack also contains evidence on the importance of taking cost-effective action now to prevent worsening impacts in a changing climate. Understanding the costs and consequences of inaction allows cost-effective and responsible decisions to be made and justified, contributing to sustainable development.

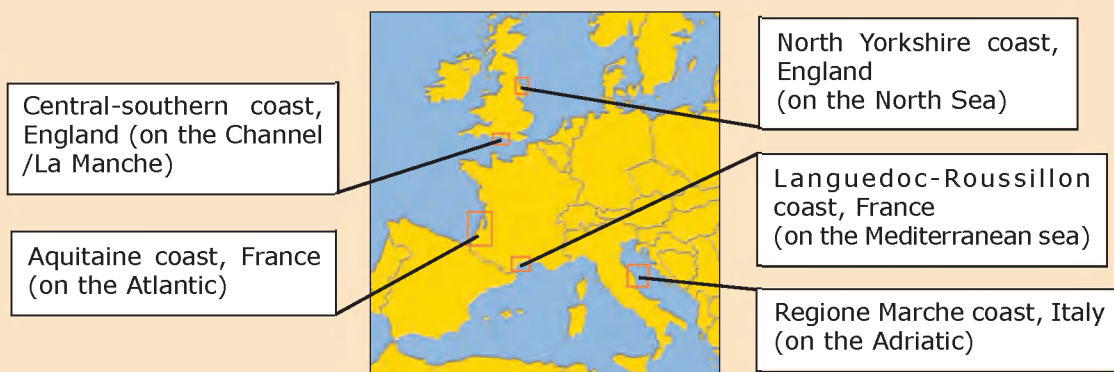
Further advice on risk reduction can be found in the partner volume, the 'Good Practice Guide', which contains advice on sustainable coastal risk management and examples from around Europe and the world of how the growing impact of natural hazards on coastal communities can be addressed and reduced.

*Plate 1: Chesil Beach, Dorset, UK*



## RESPONSE PROJECT STUDY AREAS

Coastal evolution and risk maps have been developed and tested in five 'regional' coastal study areas, each including a variety of coastal landforms:





## FREQUENTLY ASKED QUESTIONS: WHERE TO START?

Please watch the RESPONSE DVD Film which provides an introduction to coastal risks in a changing climate, and a summary of the mapping technique described in this Training Pack.

### **What is 'coastal evolution and risk mapping'?**

A technique which allows a region to take climate change predictions into account in its future planning in the coastal zone, and to understand how natural hazards may evolve in a changing climate. This is achieved by producing risk maps for the coast. The maps allow long-term changes (e.g. climate change impacts over 100 years) to be more readily embraced by planners.

### **Why is it important?**

The process of developing the maps provides a new perspective and improved understanding of the changes in patterns of risks that may be anticipated along the coastline. Existing information is incorporated and presented in a user-friendly format, which is readily understood by a non-technical audience. The maps allow the potential impacts of climate change and the future for the coastline to be communicated to decision-makers and planners in a non-sensationalised format, based on an understanding that the coastline has always evolved and will continue to do so. The magnitude and rate of change may be increasing and certain areas will be more vulnerable to climate change than others.

### **What will this report enable me to do?**

The 'Training Pack' guides the reader through the process of producing maps showing the likely future pattern of natural coastal hazards and risks across their region or sediment cell. High risk frontages will be identified as these may require particular attention to manage and reduce the levels of risk in the future.

### **Once areas of high risk have been identified, how can risks be reduced?**

Further advice on risk reduction can be found in the accompanying 'Good Practice Guide'.

### **Who can use this Training Pack, and the Maps it produces?**

The set of maps can be prepared and used by coastal managers, local/regional authority officers, engineers, practitioners and planners. The final maps in the sequence can also be used by decision-makers to understand and communicate the pattern and severity of current and future coastal risks, and prioritise their response accordingly.

### **Do I need a GIS system?**

The maps can be produced as a paper-based exercise, or by using a GIS system which allows updates to be easily incorporated and the maps to be created and viewed at a chosen scale.

### **Is the methodology for producing the maps flexible?**

Yes. The methodology has been demonstrated in five pilot regions in the UK, Italy and France, which represent the range of coastal landform types present around the European coast. The methodology can be adapted as necessary to suit all European coastlines.

### **How do you define hazard, risk and vulnerability?**

- ▷ *Hazard*: A threatening event, or the probability of occurrence of a potentially damaging phenomenon within a given time period or area;
- ▷ *Risk*: Expected loss (of lives, persons injured, property damaged and economic activity disrupted) due to a particular hazard for a given area and reference period. Based on mathematical calculations, risk is the product of hazard and vulnerability;
- ▷ *Vulnerability*: The degree to which a system is susceptible to, and unable to cope with, injury, damage or harm.

Source = European Environment Agency ([www.eea.europa.eu](http://www.eea.europa.eu))

What other information sources may be useful?

Intergovernmental Panel on Climate Change (IPCC): [www.ipcc.ch](http://www.ipcc.ch)

UK Climate Impacts Programme (UKCIP): [www.ukcip.org.uk](http://www.ukcip.org.uk)

## EXECUTIVE SUMMARY

The European coastline has experienced intense development as settlers and visitors have been attracted to the coast for strategic, economic and recreational reasons. Many coastal communities are vulnerable to hazards such as erosion, flooding and instability. The effects of climate change will put increasing pressures on Europe's expanding coastal communities. Increasing exposure to natural hazards due to the effects of climate change and an ever-increasing population inevitably result in increased risks unless sustainable coastal risk management measures can be implemented.

The coastline is a dynamic environment, influenced by coastal processes (e.g. wave energy and sediment transport) and meteorological events (e.g. storms). The coastline has been shaped by long-term forcing factors, such as dramatic changes in relative sea levels in some parts of Europe over the past 30,000 years. This has influenced the nature and severity of coastal erosion, a key factor in modifying the coastal landscape.

The Intergovernmental Panel on Climate Change predicts that climate change impacts will include sea level rise, increased winter rainfall and more intense and damaging storms - a growing threat for many coastal communities already affected by coastal erosion, flooding and instability, and an increasing challenge for the local and regional authorities responsible for addressing the resulting risks.

The costs associated with climate change and worsening natural hazards, which may be economic, social or environmental, will present an increasing burden for responsible authorities and national governments. The RESPONSE Project has demonstrated the benefits of taking preventative action now to achieve cost-effective reductions in risk and to reduce the impacts of climate change at the coast.

Sustainable development in Europe's coastal zones relies upon effective management of risk now and in the future. Strategies are needed at the various levels of government in order to understand and adapt to the challenges of coastal and climate change. By incorporating coastal hazard and risk mapping into long-term plans, local and regional authorities can divert new development away from areas of risk and seek to reduce risk in areas of existing development.

It is important that planners, engineers, coastal managers and decision-makers work together to develop and implement appropriate risk management strategies. The risk assessment methodology recommended by the RESPONSE study encourages a multidisciplinary approach to risk management to promote sustainability for Europe's coastal zones now and for future generations.

The regional-scale approach for mapping coastal evolution and risk in a changing climate was demonstrated in five European study areas. Each study area worked using a common fundamental approach to produce a homogeneous deliverable. For each map however, the mapping methodology was adapted to the available data and tools for each region. Examples of these maps are presented in this Training Pack.



*Plate 2: Beaches form a natural protection by absorbing wave energy, Międzyzdroje, Poland*

## A CALL FOR ACTION: WHY IS CLIMATE CHANGE A PROBLEM FOR COASTAL REGIONS?

Natural hazards have significant impacts on coastal zones throughout Europe. The costs of emergency action, remediation and prevention represent a significant burden to national and regional governments as well as local authorities often with limited resources. The Intergovernmental Panel on Climate Change predicts that climate change impacts will include sea level rise, increased winter rainfall and more intense storm activity, a growing threat for many coastal communities affected by erosion, flooding and landsliding, and an increasing challenge for the local and regional authorities responsible for addressing the resulting risks. In order to protect communities and assets in the coastal zone it is necessary to establish the extent of climate change impacts and implement cost-effective sustainable management policies in order to reduce the risks for future generations.

### QUOTES: WHY SHOULD WE PLAN FOR THE ANTICIPATED EFFECTS OF CLIMATE CHANGE?

#### **Environment Commissioner Stavros Dimas, European Commission:**

*"The scientific debate about the human causes of climate change is largely settled. Yet there remains an important gap between climate science and the global policy response. We cannot afford such gap. Winning the battle against climate change concerns us all. ..the time of theoretical debates about climate change is over, we need practical and effective actions."*

(Brussels, 7th July 2006; Reference SPEECH/06/444)

#### **UN Secretary-General Kofi Annan:**

*"We need to adapt to the climate change that is inevitable because of the massive accumulation of past emissions. We are far from helpless in the face of this challenge. There are many things we can do to reduce risks and protect ourselves from the extreme weather associated with climate change. Climate change still tends to be perceived as an environmental concern. But it has profound implications for jobs, growth, health and almost all other aspects of human well-being, including security."*

(New York, 28th September 2006; SG/SM/10665/ENV/DEV/903)

#### **G8 Group of Industrialised Nations:**

*"Climate change is a serious and long-term challenge that has the potential to affect every part of the globe. Adaptation to the effects of climate change due to both natural and human factors is a high-priority for all nations."*

(G8 Members: European Union, UK, France, Italy, Germany, Russia, Japan, USA, Canada; Gleneagles Communiqué, 8th July 2005)

#### **EUrosion Project- "Living with Coastal Erosion in Europe: Sediment and Space for Sustainability", commissioned by EC DG Environment:**

*'Europe's coast is under growing threat from erosion...A fifth of the enlarged EU's coastline is already severely affected, with coastlines retreating by between 0.5 and 2 metres per year, and in a few dramatic cases even by 15 metres...The estimate of the current total value of economic assets located within 500 metres of the EU's coastline, including beaches, agricultural land and industrial facilities, is €500 to €1,000 billion. Public expenditures to fight erosion are increasing. In 2001, they amounted to an estimated €3.2 billion.'*

(EUrosion Results Press Release IP/04, Brussels, 17 May 2004)

#### **Munich Re, Annual Review of Natural Catastrophes, 2005:**

*"2005 broke all negative records. Natural catastrophes have never been so expensive, either for the world's economies or for the insurance industry. It was also one of the deadliest years of recent decades."*

(Munich Re, 2006, Annual review: Natural catastrophes 2005)

#### **Dr. Gerhard Berz, Head of Geo Risks Research Department, Munich Re:**

*"Observed throughout the world in recent decades and clearly reflected in the claims burdens of the insurance industry, the increase in natural catastrophe losses is one of the first and strongest pieces of evidence that the impact of global environmental changes generated by human activity is growing."*

(Munich Re, 2006, Climate change - Modest warming, dramatic effects).





Plates 3, 4, 5: Regione Marche, Italy: left to right- The intensity of beach tourism; Rockfall on a tourist beach, Sirolo, 2006; Storm damage to the tourism infrastructure and beach profile.

Risk management is sometimes considered an expensive luxury when there is a lack of awareness of the actual risks associated with natural hazards and climate change. However, examples of the high costs associated with a lack of planning can be found from local to global scales, as discussed in the report on the accompanying CD-ROM, including investigation of economic, social and environmental costs. The economic costs of natural hazards in the coastal zone include:

- ▷ The costs of emergency response and remediation following a hazardous event;
- ▷ The costs of mitigating the effects of growing natural hazards.

The Association of British Insurers has highlighted that *"Global damages from a 0.5 metre rise in sea-level have been estimated as \$24-42bn [€19-33bn] per year. Adaptation - in the form of coastal defences - could bring these costs down to \$8-10bn [€6-8bn] per year."* (ABI, Financial Risks of Climate Change, 2005). According to the report 'Climate Change and the Financial Sector' (Allianz Group and WWF, June 2005) *"Europe is not only warming 40 percent faster than the world as a whole, but has already sustained severe damage from climate change. Storms in 1999 and floods in 2002 each cost €13billion, while a heat wave in 2003 cost €10billion. Although no precise estimate of all future costs can be made, a European Commission paper puts the future cost of all the potential cumulative global damage at €74 trillion at today's value if effective action is not taken."*

In Italy, for example, the potential significance of instability is clear. Over the last forty years major instability events have resulted in substantial loss of life and property in coastal and mountainous areas. There are several dozen deaths a year on average caused by landsliding. In the UK a Local Government Association survey in June 2004 estimated that the three most important difficulties facing local authorities in dealing with climate change are insufficient staff or staff time, other issues taking a higher profile in the council and a lack of funding.

Despite uncertainty over future conditions, there is a recognition that climate change will increasingly lead to significant rises in the costs of addressing natural hazards over the coming decades. The most significant message from this report is the increasing magnitude of the costs associated with natural hazards in the coastal zone, particularly in terms of damage to assets, protection and maintenance of defences. The costs associated with protecting these assets are small in comparison to the losses that would be incurred if no action were to be taken, thus proving relatively cost-effective, even if the assets at risk do not increase as anticipated due a legacy of past development and continuing development pressure. It will be impossible to develop strategies that negate climate change because the future level of risk cannot be defined to that level of accuracy. It is therefore only possible to decrease risk and vulnerability to natural hazards to an acceptable level.

One of the major sources of costs resulting from natural hazards is damage and losses caused as a result of development in unsuitable coastal locations. Risk management must support the planning framework as a means of reducing the impacts and costs. In this way it will be possible to create a culture of prevention, advocating cost-effective preventative action rather than costly remedial action.

**FOR THE FULL REPORT "THE ECONOMIC IMPACTS OF NATURAL HAZARDS IN COASTAL ZONES, TAKING ACCOUNT OF THE CONSEQUENCES OF CLIMATE CHANGE" PLEASE SEE SECTION 4 ON THE CD-ROM**

## **EVOLVING COASTLINES: VULNERABLE COMMUNITIES IN A CHANGING CLIMATE**

### **DYNAMIC COASTLINES**

The coast is a complex and dynamic system and slight changes in coastal processes can lead to larger scale consequences with wide-ranging implications for the entire coastal environment. Through an understanding of how the coastline has responded to historical coastal processes, it is possible to anticipate how the coast will change in future years.

An understanding of both the geology and geomorphology of the coastline is central to appreciating its past evolution and likely future response. The geological formations underlying the coast fundamentally control both the present morphology and the nature/rate of future response to environmental forcing. Sediment transport also plays a significant role in coastal processes and a study of the sedimentary system is essential to gain a clear picture of coastal processes and assess historic, contemporary and future coastal change.

In some areas, particularly those that have historically seen the greatest rates of change, the geomorphology may have been significantly altered by the activities of man. These effects are either direct, e.g. where coastal cliffs have been defended and landscaped, or indirect, e.g. where construction at one coastal location has significantly altered the coastal processes so that an adjacent or nearby coastal landform has been affected. Such alterations of natural coastal processes must be taken into consideration when assessing the potential for future change.

### **LIVING ON THE EDGE**

Human populations have always tended to favour settlement in the coastal zone. Settlements in coastal areas have risen dramatically in recent decades and are likely to continue to expand for the foreseeable future. The size of vulnerable communities will, therefore, continue to increase and the hazards they face are expected to escalate with the predicted impacts of climate change, unless firm planning policies are put in place to reduce risks.

Coastal communities are more vulnerable to climate change than inland communities because in addition to meteorological parameters, they are also affected by changes in oceanic parameters, especially increases in sea level and wave heights. Both direct effects (e.g. changes in coastal erosion, storm surges and water temperature) and indirect effects (e.g. reductions in fish stocks) will have physical and socio-economic impacts on coastal communities.

More significant than the predicted changes in average climate and sea levels will be the potential increase in the severity and frequency of extreme events such as flooding and coastal storms. Whilst coastal protection is often possible, there may be a need to improve the standards of protection in high-risk urban areas. At a strategic level, knowledge of the sensitivity of a coastline to climate change enables decision-makers to anticipate the impacts that could emerge over future decades and prioritise the management efforts to reduce the risks or to mitigate possible consequences.

In order to minimise the vulnerability and increase the adaptive capacity of coastal settlements and to optimise the opportunities presented by climate change, it is essential that we respond now to the likely impacts of a changing climate.



*Plate 6: Flooding in Fano, Italy, November 2005*



## A REVIEW OF CLIMATE CHANGE RESEARCH AND PROBABLE IMPACTS AT THE COAST: REPORT SUMMARY

The World's climate has always been changing. What is different now is that it is the strong belief of many scientists and governments that the impacts of human forcing on climate change have become discernible in addition to the natural changes. On a day-to-day basis we receive frequent reports of apparently exceptional weather conditions that have recently been recorded. For example, in the UK the 1990s was the warmest decade and 1998 the warmest year, in the instrumental record.

The most authoritative reports on the science of climate change are those produced by the Intergovernmental Panel on Climate Change (IPCC), which brings together leading experts from around the world with the objective of assessing the scientific, technical and socio-economic data relevant for the understanding of the risk of anthropogenic climate change.

*Plate 7: Selsey, West Sussex, UK. The area is protected from flooding by a groyne-stabilised beach and a seawall.*



Politically, climate change has received a considerable amount of recent attention and the predictions of climate change impacts are beginning to influence policy at the international, national and regional level. The IPCC 1992 report was fundamental to development of the UN Framework Convention on Climate Change (UNFCCC), which was agreed at the Earth Summit in Rio de Janeiro in 1992 and has been ratified by over 170 countries. The UNFCCC recognised that further cuts in global emissions were needed to prevent serious climatic impacts in the future. In 1997 the UNFCCC Conference of Parties was held in Kyoto, Japan, where a new protocol on climate change was developed. The text of the Kyoto Protocol was adopted in Kyoto on 11 December 1997. The protocol sets out to reduce climate emissions of developed countries by 5.2% below 1990 levels over the period 2008-2012. The Kyoto Protocol became a legally binding treaty on 16 February 2005. The European Environment Agency (2005) wrote, "By ratifying the UNFCCC and its Kyoto Protocol, the EU committed itself to the ultimate goal of the Convention. The objective is to stabilise greenhouse gases at levels sufficient to prevent dangerous anthropogenic climate change".

A certain amount of climate change is inevitable because of the legacy of past emissions. The potential impacts of climate change and sea level rise present a significant challenge to future coastal management and communities need to adapt to this challenge. It is anticipated that there will be increasing levels of risk to many coastal communities and assets and additional pressures on a variety of coastal zone uses, from tourism and amenity uses, marine aggregate extraction (e.g. for beach feeding programmes), port and harbour operations, to nature conservation and the protection of historical sites and monuments.

For each RESPONSE coastal study area a review has been made of:

- ▷ Availability of climate change scenarios and national/regional climate change research organisations;
- ▷ Historical and contemporary coastal processes;
- ▷ Vulnerability of coastal settlements to risk.

**FOR THE FULL REPORTS SEE SECTIONS 6 AND 7 OF THE CD-ROM**