



INNOVATIVE MANAGEMENT FOR EUROPE'S CHANGING COASTAL RESOURCE



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UNIVERSITY
OF ABERDEEN

ABERDEEN BEACH CASE STUDY

Contents

Introduction - Aberdeen beach.....	1
ECN Members:.....	3
Case study aims.....	4
Case study objectives.....	4
Learning outcomes.....	4
Key themes	5
1. Aberdeen beach historical context.....	6
1.1 Introduction.....	6
1.2 Historical context.....	6
1.3 Conclusion.....	10
1.4 Glossary	10
1.5 Information Sources	13
1.6 References.....	13
1.7 Further reading.....	13
1.8 End-of-section questions on historical context.....	14
2. Predicted changes in climate for the study area.....	15
2.1 Introduction.....	15
2.2 Changes in climate.....	15
2.3 Conclusion.....	17
2.4 Glossary	18
2.5 Information Sources	19
2.6 References.....	19
2.7 Further reading.....	20
2.8 End-of-section questions on predicted effects of climate change on Aberdeen beach	20

3. Impacts of climate change in the case study area.....	22
3.1 Introduction.....	22
3.2 Sectors to be impacted.....	22
3.3 Conclusion.....	26
3.4 Glossary.....	26
3.5 Information Sources.....	26
3.6 Further Reading.....	27
3.7 End-of-section questions on Impacts of climate change in the case study area.....	27
4. Summary and Conclusions.....	29
5. Contact details.....	30
6. Feedback.....	31
7. Answers to end-of-section questions.....	34
7.1 Aberdeen Beach historical context.....	34
7.2 Predicted changes in climate for the study area.....	37
7.3 Impacts of climate change in the case study area.....	40

List of figures

1. Map of Aberdeen coast with main areas of interest annotated.....	2
2. Aberdeen Beach, showing groynes, local attractions, beach morphology and Aberdeen harbour in the distance.....	3
3. South end of Aberdeen beach, with the harbour control tower.....	7
4. Map of area of Aberdeen beach where sand nourishment took place, groynes and granite blocks also shown.....	9
5. 90% Confidence projected changes in mean precipitation for three time ranges under UKCIP09 High Emissions Scenario.....	16
6. 90% Confidence projections of mean temperature for three time ranges under UKCIP09 High Emissions Scenario.....	16
7. a. Snow cover at Donmouth.....	17
b. Storm waves hitting Aberdeen beach.....	17
8. Exposed seawall foundations at Footdee, Aberdeen.....	22
9. Damaged seawall at Footdee.....	22
10. Main seawall at Aberdeen beach showing wave action and promenade.....	23
11. a. A simulation of a 61cm sea level rise showing areas of Aberdeen which would be flooded.....	25
b. Areas of Aberdeen classed as having a 1 in 200 chance of flooding.....	25

Introduction - Aberdeen beach

Aberdeen beach and the Queens Links area situated directly behind it (to the West) are important assets for Aberdeen City, while the nearby harbour is a major contributor to the local and regional economies and a key transport link, hosting fishing and shipping industries The kings links golf course, beach boulevard and other local amenities add to economic importance of Aberdeen beach.

The beach is located to the East of the city centre. The beach extends 3.5km from the River Dee (and Aberdeen harbour) in the South to the mouth of the River Don in the North and includes/has 30 timber groynes and blockwork revetments along its length. The study area can be seen in figure 1 on the next page.



Figure 1: Map of Aberdeen coast with main areas of interest annotated. (See map for data sources)

A view of the beach can be seen in figure 2. This photograph gives a detailed view of part of the Aberdeen beach groyne system and shows Aberdeen's harbour and some local attractions:

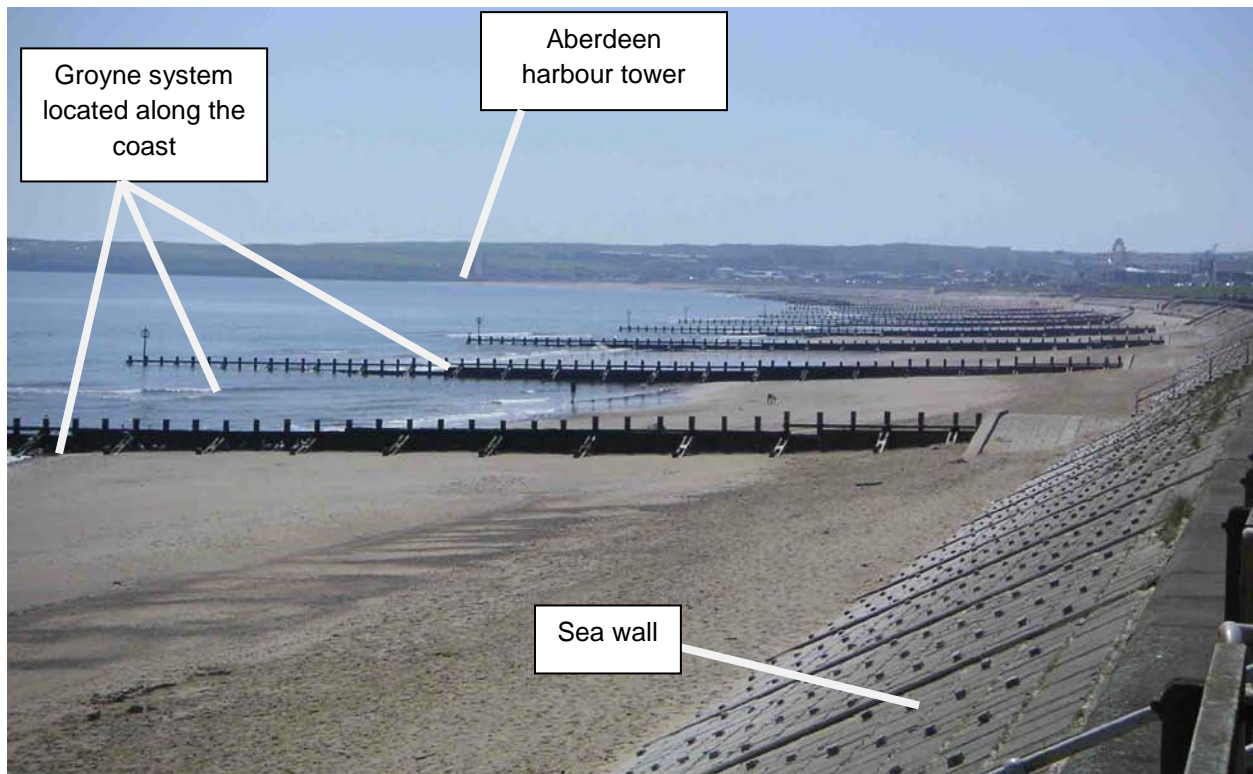


Figure 2: Aberdeen Beach, showing groynes, beach morphology and Aberdeen harbour in the distance, Aberdeen City, UK. Summer, 2008 (Guillaume De La Fons)

Expert Couplet Node (ECN) members:

- University of Aberdeen
- Aberdeen City Council

The aims of the ECN are to investigate the issues of climate change for local populations and stakeholders, focusing in particular on sea level rise, coastal flooding and erosion. Education and raising awareness among private companies, public institutions, and local communities are also key aims. These will be fulfilled by the organisation of workshops and the production of supporting material, with the eventual aim of ensuring that climate change adaptation measures are integrated into future organisational planning.

Case study aims

- To introduce the Aberdeen coast, highlight important features and provide relevant historical context
- To study the history of coastal erosion and flooding in Aberdeen and assess future events and issues with a focus on these hazards
- To identify the climate change phenomena which are likely to affect the Aberdeen coast and assess their significance in light of their predicted magnitude through the presentation of pertinent data from recent research and policy literature
- To present the likely impacts of the above effects and issues associated with developing adaptation strategies for these as identified by participants in the IMCORE Issues Identification Workshop

Case study objectives

This case study is intended to give the reader:

- Knowledge of relevant contextual information on the Aberdeen coast.
- An understanding of the uncertainty relating to the prediction of the effects of climate change, and the predictions being used to inform policy in Aberdeen.
- Knowledge of the likely environmental and economic impacts of the predicted effects of climate change in Aberdeen.
- Access to further information sources which will allow the reader to investigate climate change issues in their own area.

Learning outcomes

After studying this document and recommended reading, and answering the questions at the end of each section, the reader should have acquired the following:

- A basic knowledge and understanding of climate change issues and their effects on coastal areas

- Knowledge of the links between climate change, coastal erosion and coastal flooding, and their effects on the Aberdeen Coast
- The ability to interpret and analyse figures to help gain a better understanding of coastal climate change

Key themes

The effects of climate change on coastal erosion and flooding are the focus of this case study. The main ways in which these phenomena are likely to be affected are through predicted increases in storminess (ACC 2002) and wave velocity, as well as increases in sea level which, although predicted to be of relatively small magnitude, will nevertheless increase the vulnerability of coastal areas to damage by the sea.

The case study also examines climate change factors not directly related to the sea but which are likely to have an impact on Aberdeen, such as increases in extreme precipitation events and increases in air temperature

The study will investigate the need for beach nourishment and coastal defences in Aberdeen as an illustration of the serious problems caused by coastal erosion, and an example of issues which could become more frequent or increase in seriousness in the future as a result of climate change.

1. Aberdeen beach historical context

1.1 Introduction

In recent years Aberdeen beach has seen developments which have significantly altered the beach and will continue to affect it for the foreseeable future. This section will examine the background to these events as well as providing some contextual information on the beach and its importance to the city.

The beach is an important asset for Aberdeen City. The beach itself is also a popular tourist and recreational attraction, for example the main recreational activities include: surfing, canoeing, walking, cycling, running, shopping, cafes and swimming. The beach experiences a semidiurnal tide with a meso-tidal range. The groynes and blockwork revetments in place on the beach were installed to protect Aberdeen beach from coastal erosion. Groynes interrupt long-shore water flow, limiting sediment movement and removal, and blockwork revetments protect the shoreline from waves and flooding.

1.2 Historical context

At the South end of the beach, Aberdeen harbour is an important economic resource and trade links with other parts of Britain and the rest of the world. The main users of the harbour are vessels servicing the offshore oil and gas industry, the declining fishing fleet, importers and exporters of timber and finished paper products, and agricultural products and services. The harbour also provides a crucial transport link with Orkney and Shetland and a port of call for cruise ships.

In 2009 Aberdeen harbour handled around 5 million tonnes of cargo, with a value of approximately £1.5 billion, with a turnover of £22.17 million and pre-tax profits of £9.43 million. In figure 3 below the Aberdeen harbour tower location on Aberdeen beach can be seen in detail:



Figure 3: South end of Aberdeen beach, with the harbour control tower, Aberdeen, UK. Summer, 2008 (Guillaume De La Fons)

Directly behind the beach, north of the harbour, is an area of attractions, amusements and amenities, with many cafes and restaurants, a bowling alley, indoor and outdoor theme park and a cinema. These are the main amenities associated with the beach, and many of them are located just across the road from the sea wall. Consequently, they would be very vulnerable to damage from the sea if there were to be a failure of any of the defences.

Kings Links golf course is another main attraction at Aberdeen Beach, located behind the Northern section of the beach, running parallel to the waterfront from the mouth of the river Don to Pittodrie stadium. Kings links golf course contains 18 holes within a traditional links course. The course contains a variety of holes with a smaller 6 hole courses located at the corner of School Road. Putting and driving range facilities are also present. The course is suited for both beginners and experienced golfers due the two sizes of golf courses present and attracts a large amount of visitors all year round, since it is open through the year. It is an important tourist attraction and economic feature for Aberdeen beach.

Scotland's coast has been affected by flooding throughout its history. There have been a total of 304 flood incidents recorded over the past 150 years, one of the most significant recorded being the 1953 flood in the North East region of Scotland (including the Forth Estuary). Present annualised assessments of damage from coastal flooding are around £19 million, compared with £34.5m from fluvial flooding. Around 27 000 properties are thought to be at risk of a 0.5% annual probability (i.e. one in 200 year) coastal flood (Horsburgh, K et al 2010). This past information suggests that there will be great potential for future flooding problems for Scotland and Aberdeen.

Aberdeen beach has a history of problems with coastal erosion. Inspections in 2001 and 2004 showed that wave action had caused the removal of significant amounts of sediment from the beach. The sand elevation in front of the sea wall decreased and exposed sheet-piling, posing a risk of imminent seawall failure. Investigations showed that a failure of the sea wall would lead to the loss of sections of the esplanade and the road, as well as buildings behind the road, and the possible exposure of old tip sites currently covered by the revetment.

Concern over the vulnerability of the seawall and a possible acceleration of damage to the sea defences as a result of environmental changes associated with climate change resulted in management action by Aberdeen City Council. This took the form of a major beach nourishment and groyne construction programme along a 600m stretch of the beach, implemented in summer 2006. Below are some facts and figures on the work completed:

- 750m of pipeline constructed on the beach and used to pump sand from the dredger to the beach.
- 70 000m³ of sand were delivered through the pipeline and bulldozed into place over the course of a two week period.
- 1800 tons of Norwegian granite blocks were constructed into 3 v-shape and 2 L-shape formations and geo-textiled into the ground.

To assess the morphological response of the beach to the defence works, the Aberdeen Beach Coastal Monitoring Project (ABCoMP) was established to survey the beach both before and after the work was completed, initially using RTK GPS equipment, and subsequently with an

automated system based on high-resolution video. The project is a result of the collaboration between the University of Aberdeen and Aberdeen City Council.

In figure 4 below the area of sand nourishment can be seen in detail:

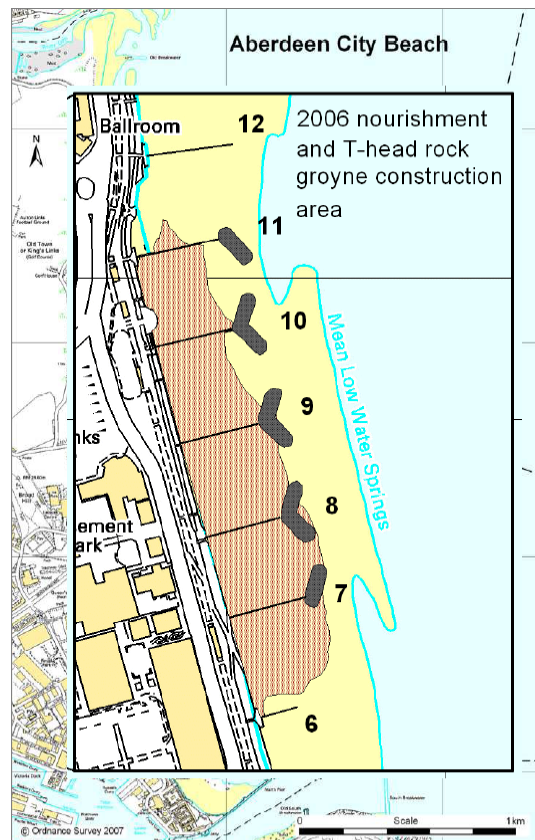


Figure 4: Map of area of Aberdeen beach where sand nourishment took place, groynes and granite blocks also shown (Source: Presentation - Amy Taylor [19.2.2010] - Aberdeen's Coastal Defences: Nourishment, Nearshore Structures and Morphological Response).

Large projects such as the beach nourishment programme affect many sectors of the economy, for example the shipping industry and transport sector will have been affected by these developments through disruption to transport links and harbour traffic. A construction of this size is also likely to have social and environmental effects; unpleasant view for beach visitors, noise pollution and habitat disruption. Future climate change factors and processes will potentially have severe effects on the above industries and may harm the economical benefit Aberdeen coast brings to the City of Aberdeen. Storminess caused by climate change has an influence on coastal erosion and flooding and will be used in this case study to show the future risks to the area.

1.3 Conclusion

Aberdeen beach is an important asset for the city, both as an amenity and for the protection it provides for commercial and private properties situated behind it. The beach is under pressure due to natural coastal processes, which could be enhanced by climate change in the future, according to current projections. Measures have been taken to restore and protect the beach, and systems have been put in place to monitor the effectiveness of these measures. However, the long term impacts, and their success in combating damage to the beach will not be known for some time, and further action may be needed in the future, depending on the impacts of climate change in the area. The next section will examine some of the predicted effects of climate change in the study area, and their possible impacts on the beach.

1.4 Glossary

- Semi-diurnal
Any cycle with two repetitions per day. In the case of tides this refers to an area experiencing two high and two low tides per day.
- Meso-tidal
A tidal range of between 1.35 and 2.9m¹
- Sheet piling
Sheet piling is a form of driven piling using thin interlocking sheets driven into the ground with impact or vibratory hammers to obtain a continuous impermeable barrier in the ground.²
Sheets can be made from a variety of materials such as steel, vinyl, plastic, wood, recast concrete and, fibreglass. Sheet piling has been a proved technology within the construction industry for years. The most

¹ http://en.wikipedia.org/wiki/Coastline_of_the_North_Sea

² http://en.wikipedia.org/wiki/Deep_foundation

recent addition was the vinyl sheets introduced in 1989. These vinyl sheets, with imperious sealants, have made this a very attractive technology for the cut-off or containment of contaminated groundwater flow in the environmental industry. Examples of its use in marine environments include: Dock Wall Stabilisation at Hendon Dock in Sunderland and Dockside Wall, Portishead in Bristol.³

- Groynes

A groyne is an active structure extending from the shore into the sea, most often perpendicularly or slightly obliquely to the shoreline. Catching and trapping of a part of sediment moving in a surf zone (mainly in a longshore direction), as well as reduction of the sediment amount transported seawards, are the principle functions of the groyne. The groynes' effectiveness increases significantly if they are employed together with other (soft) shore protection measures, like artificial beach nourishment or shore nourishment.⁴

- Revetments

Revetments are a cover or facing of erosion resistant material placed directly on an existing slope, embankment or dyke to protect the area from waves and strong currents. They are usually built to preserve the existing uses of the shoreline and to protect the slope. Like seawalls, revetments armour and protect the

³ <http://www.sheetpilinguk.com>

⁴ <http://www.coastalwiki.org/coastalwiki/Groynes>

land behind them. They may be either watertight, covering the slope completely, or porous, to allow water to filter through after the wave energy has been dissipated.⁵

- SEPA

The Scottish Environment Protection Agency (SEPA) is Scotland's environmental regulator. Their main role is to protect and improve the environment. They do this by being an excellent environmental regulator, helping business and industry to understand their environmental responsibilities, enabling customers to comply with legislation and good practice and to realise the many economic benefits of good environmental practice. They protect communities by regulating activities that can cause harmful pollution and by monitoring the quality of Scotland's air, land and water. The regulations they implement also cover the keeping and use, and the accumulation and disposal, of radioactive substances.

- Geo-textile

Geotextiles are permeable fabrics which, when used in association with soil, have the ability to separate, filter, reinforce, protect, or drain. Typically made from polypropylene or polyester, geotextiles and related products have many applications and currently support many civil engineering applications. Usually

⁵ <http://chl.erdc.usace.army.mil/chl.aspx?p=s&a=ARTICLES;141>

geotextiles are placed at the tension surface to strengthen the soil.⁶

1.5 Information Sources

- Aberdeen harbour board website:
<http://www.aberdeen-harbour.co.uk/index.html>
- Presentation on Aberdeen's Coastal Defences and Beach Nourishment. Not freely available.
A less detailed version of similar information is available from:
http://www.aberdeencity.gov.uk/Regeneration/reg/reg_Aberdeen_Beach.asp
- Aberdeen ECN information:
<http://imcore.wordpress.com/partners/aberdeen/>

1.6 References

- Horsburgh, K., Ball, T., Donovan, B. & Westbrook, G. (2010) Coastal Flooding in MCCIP Annual Report Card 2010-11, MCCIP Science Review, 10pp.
http://www.mccip.org.uk/media/6896/mccip201011_coastalflood.pdf

1.7 Further reading

- Aberdeen City Council Climate Change Action Plan, Executive Summary
<http://www.aberdeencity.gov.uk/nmsruntime/saveasdialog.asp?IID=2434&SID=904>
- Undiscovered Scotland – Aberdeen
<http://www.undiscoveredscotland.co.uk/aberdeen/aberdeen/index.html>
- Living with coastal erosion in Europe, sediment and space for sustainability (Results from the EuroSION study)
http://www.euroSION.org/project/euroSION_en.pdf

⁶ <http://en.wikipedia.org/wiki/Geotextile>

1.8 End-of-section questions on historical context

Content questions:

1. What defences does Aberdeen beach have in place that protects it from coastal erosion?
2. How do these features protect Aberdeen from coastal erosion?
3. Is Aberdeen beach susceptible to coastal erosion and flooding? Give evidence supplied in the text with your answer.
4. Describe the main features and attractions of Aberdeen beach, using both the text and figures supplied.
5. Outline the two types of flooding mentioned above and their economic damage.

Applying case study material and knowledge:

6. From using similar historical information about your local beach identify the potential climate change issues that may affect that beach.
7. Using the further reading section outline the other effects past coastal flooding has had on the UK coastline?

2. Predicted changes in climate for the study area

2.1 Introduction

Projections of the specific effects of climate change and their magnitude vary significantly according to the area under investigation, and while generalised predictions of impacts may be valid internationally, many of these may not be seen at the local level in some places. This section will draw on a range of information sources on climate impacts in the UK to show the likely impacts that climate change will have in Aberdeen, and their severity.

2.2 Changes in climate

Future climate change has the ability to bring a number of problems to Aberdeen's coastal areas. The following effects and impacts of climate change relevant to this subject area are outlined. The main observable effects of climate change for Aberdeen coast are likely to be changes in weather conditions, for example extreme weather.

Extreme weather involves temperature rise, sea temperature rise, increased precipitation, increased wave surges and storminess. These all have the potential to affect Aberdeen's coast in the future. Predicted figures for the magnitude of changes in the above climate change effects are found below. These are taken from Aberdeen City climate change action plan.

- Increased temperatures from 2° to 3.5° C by 2080
- Increase in winter rainfall by 25%
- More intense storms, with greater frequency
- Less snowfall by 90%
- 1990s 100-year storm surges are likely to be 10-20 year events by the 2050s
- Increased flood risks from rivers and sea, as well as possible sea level rise of up to 61cm by the 2080s

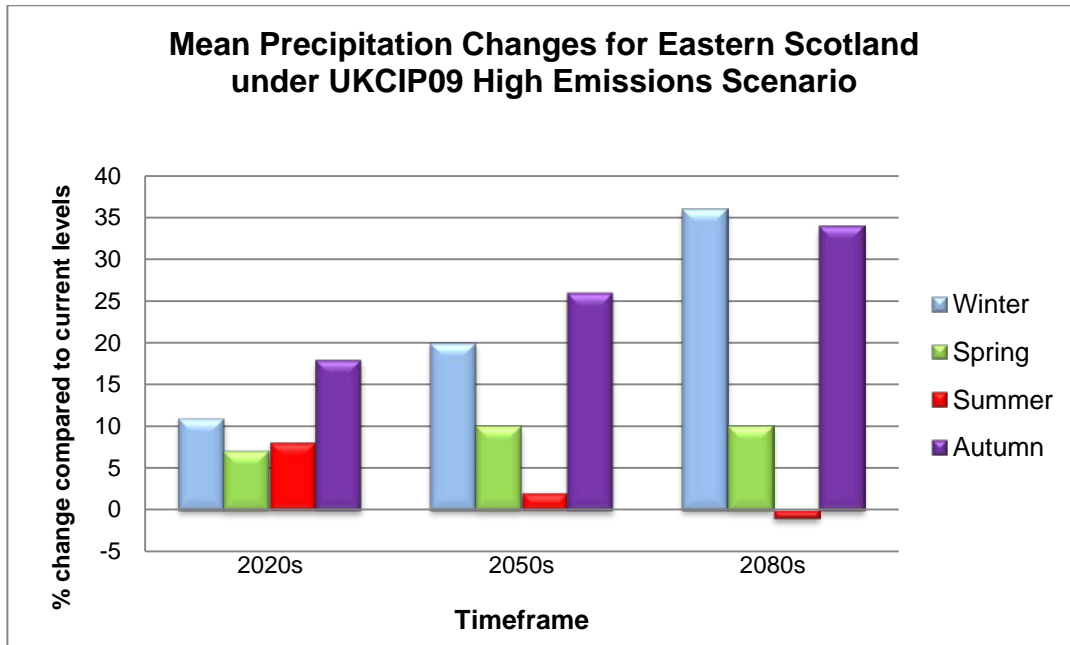


Figure 5: 90% Confidence projected changes in mean precipitation for three time ranges under UKCIP09 High Emissions Scenario. (Data Source: http://www.sccip.org.uk/Upload/Documents/SCCIP_UKCP09compendium_tables_v1.pdf)

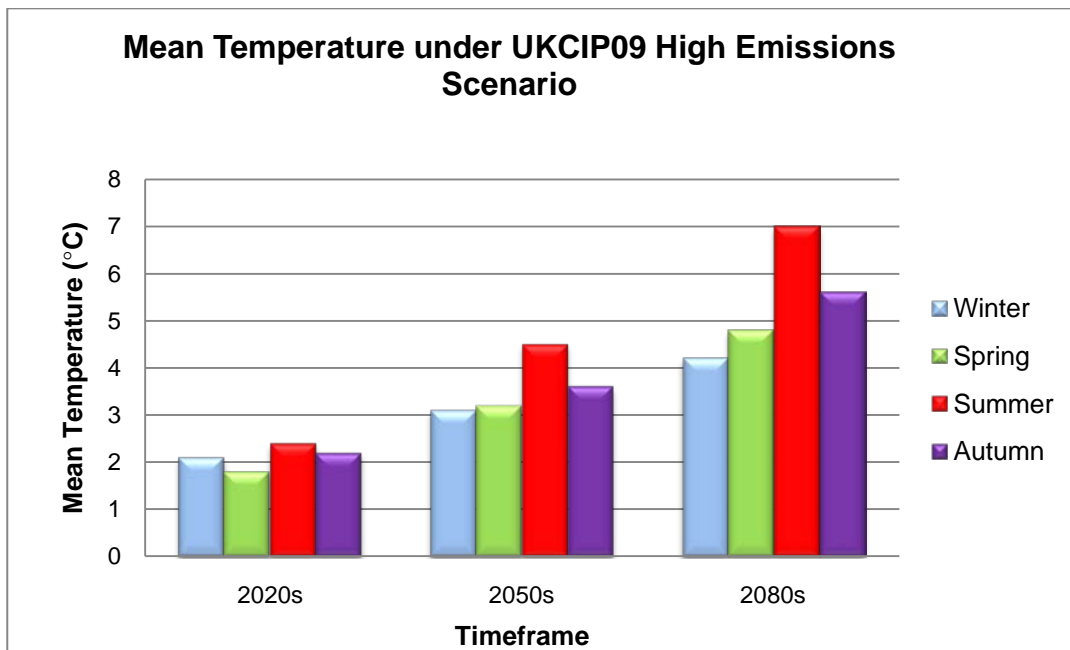


Figure 6: 90% Confidence projections of mean temperature for three time ranges under UKCIP09 High Emissions Scenario. (Data Source: http://www.sccip.org.uk/Upload/Documents/SCCIP_UKCP09compendium_tables_v1.pdf)



Figure 7a (left): Snow cover at Donmouth, Aberdeen, Winter 2009. 7b (right): Storm waves hitting Aberdeen beach. Winter, 2009. (Both Guillaume De La Fons)

The above climate change predictions; increases in storm events, rainfall, waves and sea level rise would have the biggest influence on coastal erosion and flooding. Sea level is frequently viewed as one of the most recognizable potential impacts from climate change, however according to UKCIP sea level rise will have minimal effect on NE Scotland and Aberdeen.

The other climate change factors above do have the potential to increase coastal erosion for Aberdeen's coast. Erosion will increase the likelihood of flood events. Additionally the rivers Don and Dee may be affected by the above changes, causing further flooding and damage to Aberdeen's coastal residents.

2.3 Conclusion

Although climate change is predicted to have significant effects, due to a range of favourable geographical factors Aberdeen is likely to be protected from many of these to some extent. Short to medium term impacts of climate change are likely to be relatively small in Aberdeen. However, over long periods of time, a combination of these may cause problems. Changes in precipitation and extreme weather events are likely to have the greatest impact on Aberdeen, and planning for the mitigation of climate change effects will have to address these issues.

2.4 Glossary

- Climate change

Changes identified in the mean and variability of properties in climate for an extended period of time (decades).

Climate is the average weather and the nature of its variations experienced over time. The greenhouse effect is the natural process of the atmosphere letting in some of the Sun's energy (ultraviolet and visible light) and stopping it being transmitted back out into space (infrared radiation or heat). This makes the Earth warm enough for life. Human activities, like burning coal, oil and gas, have led to an increase in greenhouse gases in the atmosphere, causing an enhanced greenhouse effect and extra warming. As a result, over the past century there has been an underlying increase in average temperatures which is continuing.

- Precipitation

In meteorology, precipitation is any product of the condensation of atmospheric water vapour that is pulled down by gravity and deposited on the Earth's surface. The main forms of precipitation include rain, snow, ice pellets, and graupel. It occurs when the atmosphere, a large gaseous solution, becomes saturated with water vapour and the water condenses, falling out of solution (i.e., precipitates). Two processes, possibly acting together, can lead

to air becoming saturated: cooling the air or adding water vapour to the air.

2.5 Information Sources

- Intergovernmental Panel on Climate Change (2007), Fourth Assessment Report
http://www.ipcc.ch/publications_and_data/publications_and_data_reports.htm
- UK Climate Projections Briefing Report
http://ukclimateprojections.defra.gov.uk/images/stories/briefing_pdfs/UKCP09_Briefing.pdf
- UK Climate Projections Science Report: Marine & Coastal Projections
http://ukclimateprojections.defra.gov.uk/images/stories/marine_pdfs/UKP09_Marine_report.pdf
- Marine Climate Change Impacts Annual Report Card 2007–2008
<http://www.mccip.org.uk/media/3007/arc2007.pdf>
- SEPA flood maps
<http://go.mappoint.net/sepa/>

2.6 References

- IPCC (2007). *Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp.
- Jenkins, G. J., Murphy, J. M., Sexton, D. M. H., Lowe, J. A., Jones, P. and Kilsby, C. G. (2009). *UK Climate Projections: Briefing report*. Met Office Hadley Centre, Exeter, UK.
- Lowe, J. A., Howard, T. P., Pardaens, A., Tinker, J., Holt, J., Wakelin, S., Milne, G., Leake, J., Wolf, J., Horsburgh, K., Reeder, T., Jenkins, G., Ridley, J., Dye, S., Bradley, S. (2009). *UK Climate Projections science report: Marine and coastal projections*. Met Office Hadley Centre, Exeter, UK.
- MCCIP (2008). *Marine Climate Change Impacts Annual Report Card 2007–2008*. (Eds. Baxter JM, Buckley PJ and Wallace CJ), Summary Report, MCCIP, Lowestoft, 8pp.

2.7 Further reading

- Hadley centre climate change guide
<http://www.metoffice.gov.uk/climatechange/guide/>
- The European Commission's "You Control Climate Change" campaign website
www.climatechange.eu.com
- IPCC Reports & supporting documents
http://www.ipcc.ch/publications_and_data/publications_and_data_reports.htm

2.8 End-of-section questions on predicted effects of climate change on Aberdeen beach

Content questions:

1. Aberdeen mean annual temperature will rise by 2080:
 - a) 0 – 0.5°C
 - b) 2 – 3.5°C
 - c) 10– 12°C
2. Which climate change predictions outlined have the potential to increase coastal erosion for Aberdeen?
3. In the 1990's a 100 year storm period was recorded for Scotland's coast. Predict whether the storm period will rise or fall by 2050. Outline a prediction for the storm activity for the 2050's.
4. In Aberdeen, the winter rainfall in 2080 is predicted to increase by:
 - a) 1%
 - b) 25%
 - c) 100%
5. Is Aberdeen predicted to experience more intense storms or less intense storms in the future? What effect will this have on coastal erosion and flooding?

Applying case study material and knowledge:

6. Through using the further reading section list all the possible effects future climate change predictions may have on Aberdeen and Scotland? Which effects are relevant to your area?

7. Which of the phenomena associated with climate change will be most severe in your area?

3. Impacts of climate change in the case study area

3.1 Introduction

As well as being manifested through different effects and with varying magnitudes in different locations, there will be a wide range of different impacts on local environments, economies, and lifestyles. This section will use the outputs from the IMCORE Issues Identification Workshop conducted in Aberdeen to explain the predicted impacts that the climate change effects identified in the previous section are likely to have on important sectors and areas in Aberdeen.

3.2 Sectors to be impacted

Sea defences

Sea level rise has a direct influence on flood damage both in terms of frequency of occurrence and extent (depth). Increased wave height and energy at the coast in areas of shallow water means more overtopping of defences. Also wave forces on defences and natural systems will be greater. Combined higher water levels (and where applicable wave heights) leads to increased mobility of soft coastal features and more likelihood of switching from a stable coastline to an eroding one. This increases pressure for new defences which in turn puts further pressure on natural systems. **Short-, Mid-, and Long-term Impact.**

Infrastructure

Impacts to shoreline and coastal erosion defences will eventually deleteriously affect infrastructure if the coastline progresses landward. Damage from increased flooding will



Figure 8: Exposed seawall foundations at Footdee, Aberdeen, UK. Summer, 2010 (Guillaume de la Fons)



Figure 9: Damaged seawall at Footdee, Aberdeen, UK. Summer, 2010 (Guillaume de la Fons)

also negatively affect coastal transportation networks. **Mid- to Long-Term Impact.**

Fisheries

Warming sea temperatures could lead to a decrease in habitat for locally important fisheries (whitefish, primarily herring and haddock), as well as an increase in invasive species (such as jellyfish) whose habitat could expand northward with a rise in temperatures. **Long-Term Impact.**



Figure 10: Main seawall at Aberdeen beach showing wave action and promenade. Aberdeen, UK. Summer, 2010. (Guillaume de la Fons)

Agriculture

Warmer temperatures, increased rainfall, and other changes in climate might alter the growing season and impact agriculture in the area. **Long-Term Impact.**

Commercial/residential areas

With current sea level rise predictions, Footdee as well as the attraction area (amusements and with many cafes and restaurants) will become more vulnerable to flooding during storms, as it is already a low lying area and has experienced flooding in the past due to its exposed location. The economic viability of this historic fishing village as a settlement could eventually be compromised if flooding proves regular. The harbour could also be vulnerable to flooding if sea level rise continues, and if its operation is significantly affected there could be repercussions for the local economy.

Limitations for adapting to issues

One factor affecting local adaptation to climate change is a perceived lack of data/information on climate change impacts, ineffective communication and organisation between organisations potentially responsible for instituting and implementing climate change adaptation policies and programmes. For instance, considering the lack of data, it was noted by attendees that little actual data on local sea level rise exists and that most of the available evidence was anecdotal.

Institutional blockages

Generally, all sectors are equally affected by the constraints on implementing climate change adaptation measures listed herein. Among the constraints are

- public apathy to adaptation;
- lack of funds to implement adaptation measures;
- lack of qualified/experienced personnel to formulate policy and implement effective adaptation strategies;
- lack of coordination across administrative organisations.

See figure 11 (following page) for maps showing simulations of flooding in Aberdeen, caused by extreme rainfall and sea level rise respectively.



Simulation of 61cm sea level rise in Aberdeen



Data sources: Ordnance Survey 1:25,000 raster map © Crown Copyright 2008
For sea level contour: Ordnance Survey PROFILE 1:10,000 DTM © Crown Copyright 2008

Areas of Aberdeen with a 1 in 200 chance of flooding



Data sources: Ordnance Survey 1:25,000 raster map © Crown Copyright 2008
Flooded areas from SEPA flood map

Figure 11a (left): A simulation of a 61cm sea level rise showing areas of Aberdeen which would be flooded. 11b (right): Areas of Aberdeen classed as having a 1 in 200 chance of flooding (i.e. these areas are predicted to flood once every 200 years) (See maps for data sources)

3.3 Conclusion

There are a wide range of threats to Aberdeen and its economic activity posed by the potential climate change. The severity of the threat depends on the magnitude of the effects, which cannot be accurately forecast, but for the short term this appears to be relatively low for individual effects. Nevertheless, the cost of mitigating all the impacts is likely to rise steadily and will represent an increasing burden for the city. A lack of knowledge, funds, experience, strong public and executive desire to robustly address climate change issues is currently impeding significant progress, but projects such as IMCORE aims to improve the situation.

3.4 Glossary

- Overtopping
When water levels exceed the height of structures which normally contain them, e.g. riverbanks or sea defences. This can be momentary (e.g. a large wave overtopping a sea wall) or longer term (e.g. high water levels leading a river to burst its banks and flood the surrounding area).

3.5 Information Sources

- Stakeholder driver and issues identification workshop (WP 2.3, 20th August 2009) report
<http://www.aberdeencimatechange.net/uploads/files/Climate%20change%20issues%20-%20Workshop4.pdf>

3.6 Further Reading

- Climate change and your community - Aberdeen

<http://www.aberdeencimatechange.net/>

- Leaflet – climate change in a coastal context

<http://www.aberdeencimatechange.net/uploads/files/Leaflet%20-%20Climate%20change%20in%20a%20coastal%20context.pdf>

- Workshop – The Impact of Climate Change on Flooding in Coastal Communities in Aberdeen and Aberdeenshire

<http://www.aberdeencimatechange.net/uploads/files/IMCORE%20Climate%20change%20workshop%2031st%20May%202010.pdf>

3.7 End-of-section questions on Impacts of climate change in the case study area

Content questions:

1. What are the main impacts climate change will have on sea wall defences?
2. Outline the main institutional blockages to climate change adaptation.
3. Are agriculture and fishing industries affected by climate change in the long term or short term?
4. From figure 5 explain whether the majority of the flooding appears to be fluvial or coastal in nature?
5. What are the causes for the flooding events seen in figure 5?

Applying case study material and knowledge:

6. Identify the areas in figure 5 that are shown to be affected by flooding.
7. What possible adaptation strategies could be developed to protect the areas you outlined in question 6?

4. Summary and Conclusions

The Aberdeen coast contains a number of significant features that are important to the city, for example the harbour and boulevard are key features located by Aberdeen beach. Current issues affecting the beach were highlighted, with flooding and coastal erosion having affected Aberdeen beach in the past. Evidence of previous erosion and flooding were supplied with identification fluvial flooding having the main impact on Aberdeen coast. Future climate change has the potential to increase the severity of these issues for Aberdeen.

The main predicted changes in climate that are most likely to have significant effects on Aberdeen were discussed in section 2. Increases in storms and associated tidal surges, extreme precipitation, and larger waves with more energy were all highlighted as phenomena linked to climate change that could increase the severity of flooding and coastal erosion along the Aberdeen coast. The predicted worst-case sea level rise of 61cm by the 2080s was simulated, but the results of the simulation were in agreement with the UKCIP prediction that the impact of sea level rise on Scotland's coastline will be minimal. Figure 5 (a) illustrates this, but also shows (5b) the possible effects of a 200 year fluvial flood, which would be much more damaging than any coastal flooding, and could become more common as a result of climate change. Aberdeen harbour and Seaton Park, in particular, were predicted to be affected by fluvial flooding.

Coastal flooding and other predicted effects of climate change could have an impact on economic activity and communities located near the Aberdeen coast, and this was discussed in detail in section 3. Sea defences, infrastructure, fisheries and agriculture were all identified as areas likely to be impacted by future climate change, along with commercial and residential property. The majority of impacts were classified as likely to be long term, with some areas, such as sea defences, likely to experience impacts across all timeframes. Limitations to adaptation and institutional blockages were also discussed in this section with the following conclusions: lack of data within organisations, public apathy to adaption, funding and coordination across organisation are the biggest problems.

Adaptation strategies to prevent the negative effects of climate change identified in the workshop were green engineering techniques, for example SUDS (Sustainable Urban

Drainage). Further informed and good planning was also highlighted, for example the continuation of not building or developing on flood plains. Education and raising awareness schemes were also mentioned. Improving flood resilience for buildings in high risk areas was identified as an adaptation strategy specifically for adaptation against flooding events. To gain a true idea of the implications climate change has to a coastal area, the history, predictions of changes in climate, impacts and limitations the IMCORE project has additional information on its website (<http://www.imcore.eu>).

5. Contact details

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6. Feedback – See page 30 for contact details to send your feedback

Please answer these questions as completely as you can to help us improve the case study.

General Feedback on the case study

1. Why did you choose this case study?

2. How would you rate the case study and its questions overall?

Please **circle** a number from 1 = did not enjoy it 3= enjoyed it 5= really enjoyed it

1 2 3 4 5

3. Overall how useful did you find the case study?

Please **circle** a number from 1 to 5; 1 not useful 3= useful and 5 very useful

1 2 3 4 5

4. Please rate the following part? 1=poor 3= average 5= excellent

Historical Context 1 2 3 4 5

Predicted changes in climate for the study area

1 2 3 4 5

Impacts of climate change in the case study area

1 2 3 4 5

Questions 1 2 3 4 5

Illustrations 1 2 3 4 5

6. What suggestions do you have for improving the case study?

Feedback on the value of the information provided

7. What was your prior understanding of climate change and its potential impacts before the case study?

Please **circle** a number from 1 to 5; 1 relatively little, 3 average, and 5 a lot

1 2 3 4 5

And now?

1 2 3 4 5

8. Was the information useful?

Yes No

Which information in particular?

9. Do you think what you have learned could be applicable to your job?

Yes No

Why? Why not?

10. Would you consider using any of the information included in the case study in your professional activities?

Yes No

If so what?

11. Do you think what you have learned is applicable to your community?

Yes No

Why? Why not?

12. Have the Illustrations help to improve your understanding of the impacts of climate change?

Yes

No

Why? Why not?

Raising Awareness about Climate Change, the Provision of Education and Training, and case study for professionals and the local community?

13. What other didactic materials would be beneficial to coastal practitioners?

14. What role do you think organisations like IMCORE should play in climate change in the local community?

15. How do you think local organisations could become more involved in projects like the IMCORE project?

16. In what ways do you feel it is best to engage the local community?

7. Answers to end-of-section questions

7.1 Aberdeen Beach historical context

Content questions:

- 1. What defences does Aberdeen beach have in place that protects it from coastal erosion?**

Answer:

The coastal defences Aberdeen Beach has in place to protect it from coastal erosion, include: groynes, blockwork revetments.

- 2. How do these features protect Aberdeen from coastal erosion?**

Answer:

Groynes interrupt long-shore water flow, limiting sediment movement and removal, and blockwork revetments protect the shoreline from waves and flooding.

- 3. Is Aberdeen beach susceptible to coastal erosion and flooding? Give evidence supplied in the text with your answer.**

Answer:

Aberdeen beach is susceptible to coastal erosion and flooding. Due to past recordings and inspections in 2001 and 2004, erosion was shown to be causing problems to the sea wall, exposing sheet-piling and compromising the wall. Previous flooding history indicates that Scotland is susceptible to flooding, with a total of 304 flood incidents recorded over the past 150 years. In 1953 the North East region of Scotland was impacted by an important flood.

4. Describe the main features and attractions of Aberdeen beach, using both the text and figures supplied.

Answer:

The main features and attractions located on Aberdeen beach include: surfing, canoeing, walking, cycling, running, shopping, cafes, Ferris wheel, Beach Boulevard and swimming. Aberdeen harbour is an important economic feature, with groynes and blockwork being other features of Aberdeen beach.

5. Outline the two types of flooding mentioned above and their economic damage.

Answer:

Coastal and fluvial flooding are the two types of flooding mentioned. Economic impact caused by these types of flooding include: assessments of damage from coastal flooding are around £19 million, compared with £34.5m from fluvial flooding.

Applying case study material and knowledge:

6. From using similar historical information about your local beach identify the potential climate change issues that may affect that beach.

Answer Guidance:

- Identify climate change information for your local area using relevant documents e.g. using UKCIP for UK beaches and IPCC documents
- Identify historical information for your beach, e.g. features and attractions
- Identify historical studies for your area e.g. Council and organisations past studies
- Use the above information gained to assess the possible climate change issues.

7. Using the further reading section outline the other effects past coastal flooding has had on the UK coastline?

Answer Guidance:

- Use the Horsburgh, K et al (2010) flooding reference to gain addition information on UK flooding.
- Use UKCIP documents to gain additional information
- Include information not supplied within the case study, focusing the whole of the UK coastline.

7.2 Predicted changes in climate for the study area

Content questions:

1. Aberdeen mean annual temperature will rise by 2080:

- a) 0 – 0.5°C
- b) 2 – 3.5°C
- c) 10– 12°C

Answer:

- b) 2 – 3.5°C

2. Which climate change predictions outlined have the potential to increase coastal erosion for Aberdeen?

Answer:

The climate change predictions; increases in storm events, rainfall, waves and sea level rise would have the biggest influence on coastal erosion

3. In the 1990's a 100 year storm period was recorded for Scotland's coast. Predict whether the storm period will rise or fall by 2050. Outline a prediction for the storm activity for the 2050's.

Answer:

The storm period is predicted to fall to 10-20 year events by the 2050s

4. In Aberdeen, the winter rainfall in 2080 is predicted to increase by:

- a) 1%
- b) 25%
- c) 100%

Answer:

b) 25%

5. Is Aberdeen predicted to experience more intense storms or less intense storms in the future? What affect will this have on coastal erosion and flooding?

Answer:

More intense storms will have the potential to increase coastal erosion for Aberdeen's coast. Erosion will see a decrease in protection from potential flooding, increase the likelihood of flood events. Additionally the rivers Don and Dee may be affected by the above changes, causing further flooding and damage to Aberdeen coastal residents.

Applying case study material and knowledge:

6. Through using the further reading section list all the possible affects future climate change predictions may have on Aberdeen and Scotland? Which affects are relevant to your area?

Answer Guidance:

- Use the Aberdeen Climate Change action to get specific future climate change affects for Aberdeen.
- Lowe, J. A et al (2009), UKCIP and IPCC documents supplied in further reading and reference section supplies information on climate change predictions and effects for Scotland.

7. Which the phenomena associated with climate change will be most severe in your area?

Answer Guidance:

- Use relevant documents which relate to your area e.g. UKCIP, and IPCC
- Use local information and knowledge about you area

7. 3 Impacts of climate change in the case study area

Content questions:

1. What are the main impacts climate change will have on sea wall defences?

Answer:

Impacts to defences will eventually deleteriously affect infrastructure with coastline progressing landward. Damage from increased flooding will also negatively affect coastal transportation networks

2. Outline the main institutional blockages to climate change adaptation.

Answer:

Generally, all sectors are equally affected by the constraints on implementing climate change adaptation measures listed herein. Among the constraints are

- public apathy to adaptation;
- lack of funds to implement adaptation measures;
- lack of qualified/experienced personnel to formulate policy and implement effective adaptation strategies;
- lack of coordination across administrative organisations.

3. Are agriculture and fishing industries affected by climate change in the long term or short term?

Answer:

Agriculture and fishing industries are affected by climate change in the long term.

4. From figure 5 is fluvial or coastal flooding the main predicted cause for flooding?

Answer:

Fluvial flooding is the main cause of flooding in figure 5

5. What are the causes for the flooding events seen in figure 5?

Answer:

Extreme rainfall and sea level rise are the causes for the flood events shown in figure 5

Applying case study material and knowledge:

5. Identify the areas in figure 5 that are shown to be affected by flooding.

- Areas around the River Don and River Dee
- Aberdeen harbour
- Seaton park
- Coastline
- Various buildings and residential areas around the river Dee

6. What possible adaptation strategies could be developed to protect the areas you outlined in question 6?

- Education
- Sea walls
- Drainage
- SUD's (Sustainable Urban Drainage)