RESILIENCE OF THE FOOD SUPPLY TO PORT FLOODING ON EAST COAST

DEFRA PROJECT FO0454

Synthesis Report

DECEMBER 2015

Kamal Achuthan, Fizah Zainudin, Jenny Roan and Taku Fujiyama
Centre for Transport Studies
Department of Civil, Environmental and Geomatic Engineering
University College London
Acknowledgements

The authors acknowledge the support offered by Defra as commissioners of this work, and other Government Departments particularly Department for Transport, Met Office and Environment Agency. The authors would like to thank all those who participated in this research, and in particular grateful to the interview, workshop participants and the Food Chain Emergency Liaison Group. Thanks to Dr. Andrew Grainger of The University of Nottingham and Peter Baker of PRB Associates for their contribution.
Table of Contents

1. Executive summary ........................................................................................................ 1
2. Introduction .................................................................................................................. 5
   2.1 Background and objectives .................................................................................... 5
   2.2 Structure ............................................................................................................... 6
3. Approach and Methodology ......................................................................................... 7
4. UK food supply .............................................................................................................. 9
   4.1 Food imports ......................................................................................................... 9
   4.2 Food production .................................................................................................... 11
   4.3 Selection of key food commodities ...................................................................... 12
5. Food supply chain industry resilience ........................................................................ 13
6. Assessment of impacts to food supplies ..................................................................... 16
   6.1 Scenarios ............................................................................................................. 16
7. Consumer behaviour .................................................................................................... 18
8. Conclusions and Recommendations ............................................................................ 21
   8.1 Discussion ............................................................................................................ 21
   8.2 Challenges and Limitations .................................................................................. 26
   8.3 Conclusions ......................................................................................................... 27
   8.4 Recommendations ............................................................................................... 28
1. Executive summary

This synthesis report presents a summary of the main findings, conclusions and recommendations from the objectives set out to achieve the Defra commissioned research project FO0454, 'Resilience of the Food Supply to Port Flooding on East Coast'. The aim of this project is to examine the effects of a potential coastal flooding event which could severely impact on the capacity of east coast ports and to inform Defra and the food supply chain industry about what factors they should consider to prepare for and respond to the incident in order to maintain supply chains and household food security.

The UK currently imports approximately 40% of the food and drink that it consumes, and more than 90% of it arrives by sea making the resilience of food imports by ports of importance to the security of supply to the UK. One of the major potential risks that could affect this is the impact of a major tidal surge on the capacity of east coast ports to continue importing food. As a number of major ports are located on the east side of the country, understanding the potential impact caused by such an event is key in developing sector resilience plans to mitigate against and respond to disruptions in the food supply chain. Currently, there is only a limited understanding due to the complex and multi-sectoral nature of food logistics. The main objectives of this project were specified as:

1. Establish an overall picture of food supplies for the UK;
2. Study and assess the impacts of major east coast tidal flooding event to recommend response measures to maintain the food supply chain;
3. Perform a literature review-based study to investigate likely consumer behaviour in response to pressures on household food security due to natural disasters.

This report combines information from the three annex reports covering various strands of this research. **Annex 1 - Modelling and analysis** addresses objectives 1 & 2, **Annex 2 - Stakeholder engagement** addresses objective 2, and **Annex 3 - Literature review: Consumer behaviour during and after natural disasters** addresses objective 3.

**Approach and method**

The UCL research team carried out this project in collaboration with Defra and the approaches adopted were specific to the objectives. In order to establish the overall picture of food supplies to the UK, 2013 information on food imports and production was acquired from publicly available datasets. Best estimates were made for lack of certain data such as the port of entry for EU food imports. For the assessment of the impacts of east coast port disruption, both engagement with stakeholders and the modelling and analysis using established data was performed to ascertain food supply chain industry response capacity/capability and resilience. Thirty seven stakeholders participated in the engagement process, these included shipping companies, port operators, third party logistics providers (3PLs), food manufacturers, retailers, and food service and catering providers. Towards the end of the project, a workshop was also held with the stakeholders, their business associations and key government departments to validate findings, exchange views and share additional knowledge. The modelling and analysis of the UK port and shipping capacity/capability for food imports and their response to east coast port disruption
scenarios was performed using MARS\textsuperscript{1} simulation model which was extended and calibrated specifically for food imports. The literature review-based study investigated likely consumer behaviour during and after natural disasters and also focussed on communications and actions of governments/companies to mitigate impacts.

**Key findings**

The analysis of UK food supply data established key ports of entry and helped identify critical commodities handled by east coast ports.

- The key ports handling food imports are Dover (18\%) plus the Channel Tunnel (8\%), London (12\%), Liverpool (10\%) and Immingham (8\%).
- The east coast ports (from Tyne to Dover) account for 57\% of UK food imports. Some of the critical food commodities identified to be handled by east coast ports in significant volumes include pig meat (69\%), fresh vegetables (65\%), palm oil (53\%) and sugar (72\%).

The engagement with food supply chain stakeholders to assess their resilience to handle longer term east coast ports disruptions revealed:

- The major east coast ports are well aware of the impacts of tidal surge and have been taking actions to minimise future disruptions. While south and west coast ports were willing to handle re-routed vessels, they do not have any plans for how to handle a sudden increase in demand, as some operators felt the facilities and resources would need to be stretched to cope with additional demands.
- Many manufacturers and retailers in general outsourced logistics and distribution to 3PLs serving UK inland logistics and expected their suppliers and shipping companies to have contingency plans. The 3PLs serving UK inland logistics however have business continuity planning for extreme weather and have flexibility incorporated into their current operations and seem to be better positioned to cope with re-routing.
- There were also some strategies to mitigate food supply disruption at different stages of the food supply chain, such as manufacturers and retailers being willing to accept available alternative products as substitutes, and catering service providers’ flexibility to change menus based on available food commodities, and prioritisation to key customers such as hospitals and schools.
- The food supply chain industry, particularly ports, shipping lines and logistics companies, expect the Government to have strategies in place to mitigate the impacts of such major east coast port disruptions. Without Government guidelines and clear communication of priorities for such emergencies, the industry feels it is difficult to determine by itself the priorities for UK resilience.
- Most fresh/chilled and perishable goods follow Just-in-Time (JIT) practice with minimum lead times from consolidation and processing facilities in Europe, relying on the reliability of short sea shipping services mainly through east coast ports. The importers of these food commodities feel that any disruption and

\textsuperscript{1} Methodology for Assessing Resilience of Seaports (MARS) is a decision support framework that includes a port operations simulation model to determine consequences for disruption scenarios and thereby assess the resilience of the system. MARS was developed by UCL and the University of Nottingham in collaboration with major ports such as London and Immingham to simulate specific port operations and analyse consequences to the system and its dependencies for any disruption scenario that could affect port operations. The MARS model is also flexible in terms of simulating multiple port operations at a macro-level and establishing consequences for imports handled by the ports.
delays to short sea shipping will lead to wastages and shortages, and the consequences will also be immediate at the retailing shelves.

- There will be issues for food inspection at alternative ports as Food Standards Agency (FSA) indicated that different systems are in practice at different ports and so may lack trained manpower required to adapt to these systems. Also around 75% of the food packaging materials come from EU countries that may be disrupted.

The modelling and analysis performed to assess ports and shipping capacity/capability showed:

- There would be disruption to food supplies imported by UK ports and the degree of disruption would vary according to the food commodity type and the shipment method. Further, the severity of the consequences will depend upon the ports disrupted as some of them have a disproportionate share and capacity in handling specific vessel types and freight units.
- MARS modelling analysis revealed that there are alternative ports available with the capacity and capability for the re-routing of RoRo and container vessels and that potentially half the disruption to food imports by freight units could be reduced by utilising re-routing optimally. Bulk commodity food imports will have issues only for longer term disruptions, but the stock levels along with production and substitution possibilities could help mitigate consequences.
- Dover is the most critical east coast port as far as food imports are concerned. The Channel Tunnel would be the only back-up for Dover but will face bottleneck as majority of stakeholders using other east coast RoRo services consider the Channel Tunnel as the main alternative, and will require its smooth running to be safeguarded by UK and French Governments.

The literature review of consumer behaviour during and after natural disasters that offered evidence of the likely behaviours along with actions by Government and industry that could mitigate impacts.

- Consumers tend to stockpile and panic buy staple, shelf-stable and dried foods such as bottled water, milk, bread, rice, pasta, canned foods, powdered milk and baby food.
- Government departments played a crucial role in mitigating impacts and their actions included campaigns to reduce panic buying, prioritisation of supplies of key commodities, and in the provision of safety information and relief efforts. Major companies cooperated with competitors to prioritise supply of key commodities and to meet increased demand from consumers.
- Social media proved to be an important platform for information sharing and to provide updates but required validation on information authenticity and accuracy from the government.

**Conclusions**

East coast ports play a major role for food imports to the UK and that disruption to some of these critical ports would affect food supplies both in short term and longer term depending upon the food commodities and their supply chain practices. Alternative routes and ports capacity exists and the disruptions could be reduced significantly, if they were utilised efficiently. Stakeholders engaged were willing to utilise all the capacity available to mitigate disruption however many felt that
disruption of this nature would need some strategies and guidelines from the Government. There are opportunities down the supply chain order to mitigate food supply disruption by prioritising supplies and using substitution of other available food commodities. It is recognised that Government and industry have a key role to play in mitigating impacts on consumer behaviour and it is clear that social media is emerging as a key communication platform.

Recommendations

The following are a selection of recommendations (see Section 8.4 for the full list):

- More engagement with the food supply chain industry is required to make key stakeholders aware of the system wide consequences and their interdependent vulnerabilities in the event of longer term port/food supply disruptions with an emphasis on the criticality of business continuity plans for such scenarios. Periodic workshops/exercises involving critical food supply chain stakeholders to discuss such low probability high impact risks will improve awareness and visibility of the interdependent risks.

- UK food suppliers’ dependence on EU refining, processing and consolidation centres leading to reliance on the reliability of short sea shipping, needs further investigation. Short sea re-routing possibilities, while available, will require further exploration and engagement with the importers, shipping agents and the freight forwarders as the RoRo ferry services will have to work in response to these stakeholders’ business demands.

- There are possibilities at the manufacturing, retailing and catering end of the supply chain to mitigate food supply disruptions including substitution and prioritisation strategies. This requires investigation beyond the limitations of commercial confidentialities and more work is needed at individual commodity flow levels to understand their contribution to the finished products to ensure consumer availability.

- Both Government and Industry need to engage more with their European counterparts to understand actions and communications required in the event of major east coast tidal surge, which may affect equally Northern European ports and UK east coast ports and could exacerbate food supply disruptions.

- Government role and support is expected by port operators, shipping lines and 3PLs in the following areas:
  - Guidelines and clear communication of priorities for critical commodities and shipments.
  - Derogations for drivers’ working hours and food labelling.
  - Priority of freight movement over passenger transport and actions to reduce bottlenecks at critical ports of entries.

- Improving flood defences and tidal barriers to protect east coast ports and critical infrastructure

- Dover and the Channel Tunnel are critical routes of entry for UK food imports and their resilience and capacity to back each other up for a longer term disruption should be studied further as an inter-dependent system. The stakeholders involved in maintaining this crucial link between UK and EU need to be engaged, made aware of the consequences, and their cooperation on joint resilience plans for disruptions is vital.
2. Introduction

The Defra commissioned research project FO0454, ‘Resilience of the Food Supply to Port Flooding on East Coast’, seeks to address the possible issues, outcomes and contingency mechanisms needed to ensure the resilience of the food supply in response to a potential coastal flooding event which could severely impact on the capacity east coast ports for months. The aim of this project is to examine the impacts, if such an east coast tidal surge were to take place, and to inform Defra and the food supply chain industry about what factors they should consider to prepare for and respond to the incident in order to maintain supply chains and household food security.

This synthesis report presents a summary of the main findings, conclusions and recommendations arising from the objectives set out to achieve this aim.

2.1 Background and objectives

Defra policy responsibility for food includes leading on the resilience of the food supply chain in terms of its preparedness for events that could potentially threaten household food security. The UK currently imports approximately 40% of the food and drink that it consumes. While a balance of trade and integration with world markets is important from an overall food security perspective and for protection against shocks in domestic production, this necessarily makes the resilience of food imports of importance to the security of supply to the UK. Being an island nation, UK ports serve as the gateways to all imports, and more than 90% of food imports arrive by sea. One of the major potential risks in the UK National Risk Assessment (NRA) that could affect the food industry is the impact of a major east coast tidal surge on the capacity of ports on the east coast to continue importing food, and the disruption it could cause to the availability of certain key commodities. As a number of major ports are located on the east side of the country, understanding the potential impact caused by such an event is key in developing sector resilience plans to mitigate against and respond to disruptions in the food supply chain.

The principal challenges lie in the complex and multi-sectoral nature of food logistics. Firstly, there is a lack of detailed data on how food comes to the UK, particularly regarding foods of EU origin that account for nearly 67% of UK food imports, which ports they enter by and the logistics required to transport them. Secondly, the UK food supply depends on a wide range of companies and organisations including ports, shipping lines, importers, freight forwarders, food manufacturers, wholesalers and retailers that form a complex chain which is sophisticated and specific for certain food commodities. While this complex system offers a number of different supply chains, which in itself makes this system resilient, there also exist complex inter-dependencies and lean practices to improve efficiency such as Just-in-Time (JIT). This necessitates that the food supply chain stakeholders be made aware of vulnerabilities and engaged to better understand their contingency and business continuity plans in the face of disruptions.

Analysing and assessing impacts to food supplies in the case of a potential coastal flooding event disrupting east coast ports requires an understanding of these
stakeholders’ capabilities, particularly of the UK ports’ and shipping companies’ capability to respond to such an event. A previous related study commissioned by Defra, *Resilience of the Food Supply Chain to Port Disruption*, published in October 2012, provided an understanding of the impacts of disruptions on some major ports, but not for a major east coast port disruption scenario involving multiple ports. The study recommended that modelling of ports and shipping capacity along with their capability was needed for impact assessments of port disruptions. Methodology for Assessing Resilience of Seaports (MARS) is a decision support framework that includes a port operations simulation model to determine consequences for disruption scenarios and thereby assess the resilience of the system. MARS was developed by UCL and the University of Nottingham in collaboration with major ports such as London and Immingham to simulate specific port operations and analyse consequences to the system and its dependencies for any disruption scenario that could affect port operations. The MARS model is also flexible in terms of simulating multiple port operations at a macro-level and establishing consequences for imports handled by the ports.

Finally, an understanding of consumer needs and response to such an event is also required to inform approaches of the Government and food industry in order to mitigate impacts and ensure a continuous supply of nutritious and quality food products to the UK population.

Therefore, the main objectives for this project are:

1. Establish an overall picture of food supplies for the UK;
2. Study and assess the impacts of major east coast tidal flooding event to recommend response measures at the policy level to maintain the food supply chain;
3. Perform a literature review-based study to investigate likely consumer behaviour in response to pressures on household food security due to natural disasters.

### 2.2 Structure

This report synthesises information from the three annex reports covering various strands of this research. *Annex 1- Modelling and analysis* addresses objectives one and two, *Annex 2 - Stakeholder engagement* addresses objective two, and *Annex 3 - Literature review of consumer behaviour during and after natural disasters* specifically addresses objective three.

Following this section, the report is organised as below:

Section 3: Approach and Methodology: outlines the approach and methods set out to achieve the objectives.

Section 4: UK food supply: presents an overview of food supplies for the UK, presents key statistics of ports of entry for food imports and identifies key commodities imported by east coast ports.
Section 5: Food supply chain industry resilience: summarises the key findings from the stakeholder engagement process and include the impacts on their operations and their strategies to handle longer term east coast port disruptions.

Section 6: Assessment of impacts to food supplies: discusses the assessment of impacts on by shipment types and selected food commodities for east coast port disruption scenarios

Section 7: Consumer behaviour: presents the key findings of the literature review-based study carried out to investigate likely consumer behaviour and communications and actions of governments and companies, during and after natural disasters.

Section 8: Conclusions and recommendations: discusses the key findings along with their limitations, leading on to overall conclusions and recommendations

3. Approach and Methodology

The UCL research team carried out this project in collaboration with Defra. The work program had provision for UCL researchers to be seconded into the Defra Food Policy Unit (FPU), which allowed a close working relationship with policy, science and technical knowledge experts, for knowledge exchange and the establishment of internal and external stakeholder contacts relevant for this project. The approaches adopted were specific to achieve the three objectives set out in Section 1.1.

In order to establish the overall picture of food supplies to the UK, 2013 information on food imports was acquired from the UK trade statistics data published by HMRC, and UK food production statistics for crops and livestock, presented in Defra’s ‘Agriculture in the UK’ publication. While detailed ports of entry data for Non-EU goods was available in the HMRC publication, this data was not recorded for EU goods. PRB Associates, who carried out the earlier study commissioned by Defra on port disruption, had derived estimates for ports of entry for EU food imports as part of that study. This project relied on the expertise of PRB Associates to carry out this piece of work and present the best estimates for EU food imports by UK ports of entry. The range of food imports arriving by east coast ports was discussed with Defra food supply resilience specialists in order to select four key commodities that were then assessed in detail for the impacts of east coast port disruption. The UK food supply data, methodology used, along with estimates of PRB Associates are detailed in Annex 1, while the key food supply statistics established and commodities selected are presented in Section 3.

The main objective of this research is to study and assess the impacts of a major east coast tidal flooding event on food supplies (specifically on food imports due to port disruption) and to recommend likely actions required by Government and industry to respond to it. The key tasks that were performed to achieve this objective included:

- Engagement with stakeholders to ascertain food supply chain industry response capability and resilience (to longer-term east coast disruptions)
- Modelling and analysis of the UK port and shipping capacity/capability to respond to east coast port disruption scenarios.
The UK food supply chain stakeholder groups to be engaged were determined at an early stage of the research project and included shipping companies, ports, third party logistics providers (3PLs), food manufacturers, retailers, and food service and catering providers. Relevant trade associations and government departments were also listed as targeted stakeholders. The stakeholders were selected based on their reliance on food imports and their position in the UK food industry. Thirty seven stakeholders participated and various data collection mechanisms were employed throughout the engagement process including face-to-face interviews, telephone interviews and email responses. Towards the end of the project, a workshop was also held in which the stakeholders, their business associations and key government departments such as Cabinet Office, Department for Transport, Department for Communities and Local Government, the Met Office, the Environment Agency, along with Defra participated to validate findings, exchange views and share additional knowledge. Throughout this process, food industry stakeholders were made aware of tidal surge as a threat and the potential disruption it could cause to east coast port operations. In turn, we gained information on impacts on their operations, responses and business continuity plans for such a disruption and their strategies in general for reducing disruption and improving the resilience of UK food supply chains. The detailed methodology and key findings of this task are presented in Annex 2.

While an understanding of stakeholder responses and strategies for east coast port disruption is useful, it is the analysis of such responses using the available UK ports of entry capacity and capability that is crucial in offering an assessment of food supply resilience for port disruptions. To achieve this, the MARS model was extended and calibrated to analyse the UK ports and shipping capacity for food import disruptions. The methodology involved is detailed in Annex 1. The key steps involved were: collecting data on UK port and shipping capacity and capability; analysing food and maritime statistics to model the food import flow; calibrating the model and testing the outputs to match with real data for the simulation of the normal operation scenario; and modelling the re-routing logic for vessels during a port disruption scenario and verifying assumptions and outputs with SMEs and key stakeholders. Two scenarios of east coast port disruption were designed in consultation with Defra, the Met Office and EA experts specifically for the modelling assessment. The MARS model was applied for most of the analysis while, for certain food shipments that relied on special handling and processing, an analysis based on stakeholder feedbacks of re-routing possibilities, stock levels, local production capacities and substitution options was considered.

A literature review-based study was carried out to investigate likely consumer behaviour in response to pressures on household food security due to natural disasters. The review specifically focussed on consumer behaviour, communications and actions of governments and companies, and social media usage during and after natural disasters, with emphasis on the impact to the supply and consumption of food and drink. The selected evidence base consisted of a mixture of peer reviewed academic papers, government reports, analysis of market research and anecdotal evidence. The literature review framework and methodology are presented in Annex 3, while the key findings are summarised in Section 6.
4. UK food supply

The key food supply statistics that helped identify critical food commodities handled by east coast ports are presented in the sections below:

4.1 Food imports

UK trade statistics data is published by HMRC using the UK trade info (UKTI) website that has records of the movement of goods between the UK and other countries. Analysing the UKTI database for inward movement of goods in 2013, for food commodities as identified by Defra at the 2-digit SITC level, revealed that the UK imported 39.4 million tonnes of food commodities (Table 1). It can be seen from the table that EU food imports account for 26.2 million tonnes (66%), almost double the volume of food imported from Non-EU countries that accounts for 13.2 million tonnes. Vegetables and fruits account for most of the imports (26%), followed by cereals and cereal preparations (19%). In addition, these commodities, along with beverages (10%) and meat (5%), are imported in significantly higher volumes from EU compared to Non-EU sources. Only a few commodities such as sugar, feeding stuff for animals, fish, oil seeds & oleaginous fruits were imported more from Non-EU countries than from the EU. The UK being an island, most of these imports are transported by ship and are handled through UK ports. A small proportion of these arrive by rail, mainly through Channel Tunnel freight shuttles, and a small amount by air. The following subsection establishes and presents the estimates of UK ports of entry for these food commodities.

Table 1 UK Food Imports, by Commodity (tonnes)

<table>
<thead>
<tr>
<th>Food Commodity (SITC2)</th>
<th>EU</th>
<th>Non-EU</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 - Meat &amp; meat preparations</td>
<td>1,706,637</td>
<td>383,369</td>
<td>2,090,007</td>
</tr>
<tr>
<td>02 - Dairy products &amp; birds' eggs</td>
<td>1,503,691</td>
<td>10,132</td>
<td>1,513,823</td>
</tr>
<tr>
<td>03 - Fish, crustaceans, molluscs &amp; aq. inverts &amp; preps thereof</td>
<td>239,631</td>
<td>500,010</td>
<td>739,641</td>
</tr>
<tr>
<td>04 - Cereals &amp; cereal preparations</td>
<td>5,623,675</td>
<td>1,680,122</td>
<td>7,303,796</td>
</tr>
<tr>
<td>05 - Vegetables &amp; fruit</td>
<td>6,875,980</td>
<td>3,461,092</td>
<td>10,337,071</td>
</tr>
<tr>
<td>06 - Sugar, sugar preparations &amp; honey</td>
<td>1,196,524</td>
<td>1,429,626</td>
<td>2,626,149</td>
</tr>
<tr>
<td>07 - Coffee, tea, cocoa, spices &amp; manufactures thereof</td>
<td>528,100</td>
<td>445,103</td>
<td>973,203</td>
</tr>
<tr>
<td>08 - Feeding stuff for animals (not inc. unmilled cereals)</td>
<td>2,743,858</td>
<td>2,898,560</td>
<td>5,642,418</td>
</tr>
<tr>
<td>09 - Miscellaneous edible products &amp; preparations</td>
<td>1,345,680</td>
<td>199,333</td>
<td>1,545,013</td>
</tr>
<tr>
<td>11 - Beverages</td>
<td>3,206,887</td>
<td>871,011</td>
<td>4,077,898</td>
</tr>
<tr>
<td>22 - Oil seeds &amp; oleaginous fruits</td>
<td>270,761</td>
<td>748,520</td>
<td>1,019,280</td>
</tr>
<tr>
<td>41 - Animal oils &amp; fats</td>
<td>69,232</td>
<td>14,121</td>
<td>83,353</td>
</tr>
<tr>
<td>42 - Fixed vegetable fats &amp; oils, crude, refined, fractionated</td>
<td>663,785</td>
<td>486,819</td>
<td>1,150,605</td>
</tr>
<tr>
<td>43 - Animal or vegetable fats &amp; oils, processed, &amp; waxes</td>
<td>212,178</td>
<td>84,374</td>
<td>296,552</td>
</tr>
<tr>
<td>Total</td>
<td>26,186,619</td>
<td>13,212,192</td>
<td>39,398,809</td>
</tr>
</tbody>
</table>
4.1.1 Ports of Entry

One of the main objectives of this study is to establish the ports of entry for the imported food commodities. While this data is available for Non-EU imports at a detailed commodity level including the source of imports, the EU goods arriving at UK ports of entry, including food commodities, are not recorded as part of the Customs import and export entries. The UKTI data does publish the volumes of trade movement between EU countries, estimated based on an EU-wide Interstat survey, at detailed commodity levels. Based on this, it is only possible to estimate the specific volumes of EU food commodities imported through individual UK ports. PRB Associates carried out an analysis to estimate EU food commodity imports by UK ports, and the details of the methods, assumptions and associated tables are presented in Sub-Annex 1 of Annex 1. Table 2 below summarises the overall food import volumes established for major UK ports of entry from both Non-EU and EU countries.

Table 2 Food imports handled by major UK ports

<table>
<thead>
<tr>
<th>Port of Entry</th>
<th>Non-EU</th>
<th>EU</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tonnes</td>
<td>%</td>
<td>Tonnes</td>
</tr>
<tr>
<td>Dover</td>
<td>284,012</td>
<td>2</td>
<td>6,706,292</td>
</tr>
<tr>
<td>London</td>
<td>2,904,641</td>
<td>23</td>
<td>1,645,891</td>
</tr>
<tr>
<td>Liverpool</td>
<td>2,726,526</td>
<td>21</td>
<td>1,252,474</td>
</tr>
<tr>
<td>Immingham</td>
<td>603,886</td>
<td>5</td>
<td>2,679,065</td>
</tr>
<tr>
<td>Channel Tunnel</td>
<td>0</td>
<td>0</td>
<td>3,155,775</td>
</tr>
<tr>
<td>Felixstowe</td>
<td>2,267,417</td>
<td>18</td>
<td>431,135</td>
</tr>
<tr>
<td>Belfast</td>
<td>1,288,850</td>
<td>10</td>
<td>1,318,951</td>
</tr>
<tr>
<td>Hull</td>
<td>321,905</td>
<td>2</td>
<td>1,045,324</td>
</tr>
<tr>
<td>Bristol</td>
<td>717,489</td>
<td>6</td>
<td>434,866</td>
</tr>
<tr>
<td>Holyhead</td>
<td>0</td>
<td>0</td>
<td>1,068,256</td>
</tr>
<tr>
<td>Portsmouth</td>
<td>589,544</td>
<td>5</td>
<td>464,908</td>
</tr>
<tr>
<td>Other Ports</td>
<td>1,201,486</td>
<td>9</td>
<td>5,988,325</td>
</tr>
<tr>
<td>Total</td>
<td>12,905,756</td>
<td>67</td>
<td>26,191,262</td>
</tr>
</tbody>
</table>

In terms of the UK ports handling food commodities from the Non-EU sources, London (23%), Liverpool (21%) and Felixstowe (18%) play a major role and the majority of food commodities will tend to be either non-indigenous or bulk shipments. For EU imports, it is estimated that Dover (26%) and the Channel Tunnel (12%) are the major ports of entry, followed by Immingham (10%) and London (6%). Overall, the main UK ports of entry for food commodity imports from both EU and Non-EU sources are therefore Dover (18%), London (12%), Liverpool (10%), Immingham (8%) and the Channel Tunnel (8%).

4.1.2 Food imports by east coast ports

From the previous section, it is clear that many east coast ports, namely Dover, London, Immingham and Felixstowe plus the Channel Tunnel, play a major role in handling food commodity imports to the UK. Since the focus of this study is to assess impacts to food imports in the event of east coast ports disruption, Table 3 presents the tonnages of food commodities and the percentage share handled by the east coast ports from Tyne to Dover.
Table 3 Food imports handled by east coast ports

<table>
<thead>
<tr>
<th>Food Commodity (SITC2)</th>
<th>Tonnes</th>
<th>% share</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 - Meat &amp; meat preparations</td>
<td>1,282,158</td>
<td>61</td>
</tr>
<tr>
<td>02 - Dairy products &amp; birds’ eggs</td>
<td>755,280</td>
<td>50</td>
</tr>
<tr>
<td>03 - Fish, crustaceans, molluscs &amp; aq. inverts &amp; preps thereof</td>
<td>539,469</td>
<td>73</td>
</tr>
<tr>
<td>04 - Cereals &amp; cereal preparations</td>
<td>2,685,610</td>
<td>49</td>
</tr>
<tr>
<td>05 - Vegetables &amp; fruit</td>
<td>6,809,455</td>
<td>66</td>
</tr>
<tr>
<td>06 - Sugar, sugar preparations &amp; honey</td>
<td>1,970,608</td>
<td>73</td>
</tr>
<tr>
<td>07 - Coffee, tea, cocoa, spices &amp; manufactures thereof</td>
<td>719,319</td>
<td>74</td>
</tr>
<tr>
<td>08 - Feeding stuff for animals (not inc. unmilled cereals)</td>
<td>1,697,699</td>
<td>30</td>
</tr>
<tr>
<td>09 - Miscellaneous edible products &amp; preparations</td>
<td>972,862</td>
<td>63</td>
</tr>
<tr>
<td>11 - Beverages</td>
<td>2,837,160</td>
<td>70</td>
</tr>
<tr>
<td>22 - Oil seeds &amp; oleaginous fruits</td>
<td>316,942</td>
<td>32</td>
</tr>
<tr>
<td>41 - Animal oils &amp; fats</td>
<td>42,793</td>
<td>51</td>
</tr>
<tr>
<td>42 - Fixed vegetable fats &amp; oils, crude, refined, fractionated</td>
<td>780,526</td>
<td>68</td>
</tr>
<tr>
<td>43 - Animal or vegetable fats &amp; oils, processed, &amp; waxes</td>
<td>230,727</td>
<td>78</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>22,521,343</strong></td>
<td><strong>57</strong></td>
</tr>
</tbody>
</table>

In terms of the total food volumes imported, it can be seen that the east coast ports handle more than half of UK imports (57%). For certain commodities, such as beverages, fish, sugar and coffee/tea, the share is more than 70%. Except for food commodities that are shipped in bulk, such as oil seeds & oleaginous fruits and feeding stuff for animals, for all other commodities the east coast ports account for at least 50% of UK imports. Specifically, the other key commodities imported in large volumes through east coast ports are fixed vegetable fats and oils (68%), which include all cooking oils such as palm, sunflower oil etc., vegetables and fruit (67%), and all meat and meat preparations (61%).

4.2 Food production

UK food production statistics for crops and livestock are published as part of Defra’s ‘Agriculture in the UK’ publication. The data coverage focusses only on key products. The trade data for these products is compared to derive the production as a percentage of supplies (imports + production – exports). Table 4 summarises the relevant data extracted from the publication. Staple products such as cereals, wheat and barley along with milk have higher production to supply ratio (80% and above) as these are produced in large volumes in the UK, supplemented only by small volumes of imports. Similarly, the local production almost meets the demand for cattle, sheep, poultry and their meat along with hen eggs. It is the demand for fresh produce, particularly fruits and items that are mostly non-indigenous to UK that is being met significantly by imports. Other key products that have a low production to supply ratio (around 60%) and imported in larger volumes are sugar, and pigs and pig meat.
Table 4 Food production and supply in 2013 (Source: Agriculture in the UK datasets, Defra)

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Volume in thousand tonnes</th>
<th></th>
<th></th>
<th>Production as % of total new supply for use in the UK</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Production</td>
<td>Import</td>
<td>Export</td>
<td>Total New Supply</td>
</tr>
<tr>
<td>Fresh fruit</td>
<td>388</td>
<td>3561</td>
<td>147</td>
<td>3,803</td>
</tr>
<tr>
<td>Fresh vegetables</td>
<td>2,608</td>
<td>2237</td>
<td>81</td>
<td>4,764</td>
</tr>
<tr>
<td>Sugar beet and sugar</td>
<td>1,320</td>
<td>1113</td>
<td>233</td>
<td>2,200</td>
</tr>
<tr>
<td>Pigs and pigmeat</td>
<td>791</td>
<td>723</td>
<td>207</td>
<td>1,306</td>
</tr>
<tr>
<td>Potatoes</td>
<td>5,685</td>
<td>2347</td>
<td>480</td>
<td>7,552</td>
</tr>
<tr>
<td>Cattle and calves; beef and veal</td>
<td>842</td>
<td>305</td>
<td>127</td>
<td>1,019</td>
</tr>
<tr>
<td>Wheat</td>
<td>11,921</td>
<td>2966</td>
<td>448</td>
<td>14,439</td>
</tr>
<tr>
<td>Cereals</td>
<td>20,083</td>
<td>5085</td>
<td>1450</td>
<td>23,788</td>
</tr>
<tr>
<td>Hen Eggs (million dozens)</td>
<td>829</td>
<td>153</td>
<td>23</td>
<td>958</td>
</tr>
<tr>
<td>Poultry and poultrymeat</td>
<td>1,662</td>
<td>479</td>
<td>304</td>
<td>1,838</td>
</tr>
<tr>
<td>Oats</td>
<td>964</td>
<td>66</td>
<td>17</td>
<td>1,013</td>
</tr>
<tr>
<td>Sheep and lambs; mutton and lamb</td>
<td>300</td>
<td>120</td>
<td>119</td>
<td>301</td>
</tr>
<tr>
<td>Milk (million litres)</td>
<td>13,546</td>
<td>132</td>
<td>473</td>
<td>13,205</td>
</tr>
<tr>
<td>Barley</td>
<td>7,092</td>
<td>195</td>
<td>849</td>
<td>6,438</td>
</tr>
<tr>
<td>Oilseed rape</td>
<td>2,128</td>
<td>177</td>
<td>431</td>
<td>1,875</td>
</tr>
<tr>
<td>Linseed</td>
<td>62</td>
<td>13</td>
<td>37</td>
<td>38</td>
</tr>
</tbody>
</table>

4.3 Selection of key food commodities

The study aimed to perform the assessment of impacts for east coast port disruption scenarios using only selected food commodities. The selection of the commodities was based on discussions with Defra food supply resilience specialists after the UK food supply data had been established. Some of the criteria applied for selection were:

- Percentage of imports handled by east coast ports (Table 3), and specifically if they are non-indigenous to UK
- Commodities with low production to supply ratio (Table 4)
- Commodity type: raw materials and basic ingredients that require refining and processing; perishables such as fresh produce, meat etc. imported directly to retail shelves
- Specialized supply chain practices involved in transport and storage such as temperature controlled (chilled frozen or heated) and products, and the JIT supply chain

Table 5 presents the four key commodities selected and their criteria fit.
**Table 5 Selected key food commodities**

<table>
<thead>
<tr>
<th>Commodity</th>
<th>East Coast Share</th>
<th>Production to Supply Ratio</th>
<th>Important Elements/ Special Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pig Meat</td>
<td>69%</td>
<td>61%</td>
<td>• Temperature controlled handling facilities and transport (chilled/frozen)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Needs processing and packaging</td>
</tr>
<tr>
<td>Fresh Vegetable</td>
<td>65%</td>
<td>55%</td>
<td>• Perishable and JIT supply chain</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Consolidation/Direct to shelves</td>
</tr>
<tr>
<td>Palm Oil</td>
<td>53%</td>
<td>Non-indigenous</td>
<td>• Raw material needs refining</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Most widely used vegetable oil in UK</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Specialized handling facilities and storage (heated tanks)</td>
</tr>
<tr>
<td>Sugar</td>
<td>72%</td>
<td>60%</td>
<td>• Basic ingredient</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Needs refining</td>
</tr>
</tbody>
</table>

**5. Food supply chain industry resilience**

This section will summarise the findings from the stakeholder engagement process. The key findings summarised by different stakeholder groups below include the impacts on their operations and their strategies to handle longer term east coast port disruptions.

**Shipping Companies**

- Some deep-sea container vessels would re-route, while others would prefer to skip UK ports and unload containers at European ports. The decision on re-routing of deep-sea containers would be made by their shipping alliances.
- Deep-sea container vessels would consider re-routing to the ports of Southampton, Liverpool, Le Havre and ports in Spain if Felixstowe was disrupted. One company preferred re-routing to UK alternative ports as it would be more cost effective for their customers than unloading in Europe and transhipping.
- Re-routing of short sea ferries and container services was not considered feasible as their clients would find alternative routes that would be more cost effective. The Channel Tunnel would be the best alternative option to accommodate the loss of shipments from accompanied and unaccompanied freight operations. There was also a suggestion that vessels serving such disrupted short sea links could be moved to unaffected ports between Europe and the UK.

**Ports**

- While east coast ports are vulnerable to tidal surge, many of the major ports are well aware of the impacts and have been taking actions to minimise future disruptions, including moving engineering facilities to safer locations, determining critical assets and improving the safety of substations for power at their ports. They also discussed that there are ongoing improvements to tidal barriers, lock gates and flood defences at the ports.
South and west coast ports would be willing to handle re-routed vessels. However, opinions varied among the port operators, based on the ownership of the ports, as some felt the facilities and resources would not be able to cope with additional demands. Some other operators felt that they would be able to manage any additional demand as long as the vessels could be handled at their port.

Some of the south and west coast ports suggested that, to cope with additional demand during a disruption of east coast ports, they would have to create temporary additional storage spaces to handle containers and trailers within the port estate. Their resources would be stretched and they would rely on cooperation with other food supply chain stakeholders, particularly shipping and logistics companies.

Third Party Logistics Providers (3PLs)

- The 3PLs serving UK inland logistics stated that they have business continuity planning for extreme weather such as road network problems, access restrictions to warehouses etc. They also highlighted that they have flexibility within their current operations and would be well positioned to cope with re-routing.
- More resources such as trucks and drivers would be required as there could be a higher demand for logistics solutions from non-customers at alternative ports.
- On-going cooperation with external agencies such as the Highways Agency would help them to deal with disruptions to the current logistics network.

Importers of Fresh and Chilled Food Commodities

- All importers indicated that products such as fresh meat and fresh produce are susceptible to delays due to their short product shelf life and JIT replenishment of shipments and deliveries.
- Importers keep very low inventory levels at facilities throughout the UK. Any delays due to disruption to east coast ports would result in product wastage and supply disruptions.
- The importers would use the Channel Tunnel as an alternative route of supply from the EU into the UK.

Importers and Refiners of Dry and Liquid Bulk Commodities

- Due to longer shelf life and higher stock levels in the UK, it was highlighted that there would be no immediate impacts from disruption to east coast ports on the product supply to the customers. However, the impact would be felt if the disruptions were sustained for longer periods.
- During prolonged disruptions, the importers would re-route shipments to other ports that have the required handling and storage facilities for bulk commodities. However, the commodities would need to be further transported to their refinery or processing facilities on the east coast.
Food Manufacturers

- The manufacturers keep very low inventory levels at their facilities. The manufacturers expect their suppliers to have contingency plans in place in the event of any disruption to east coast ports.
- They also stated that they have the flexibility to find alternative sources of supply and change the recipes of products in the event of prolonged disruption.
- Any increases to the cost of getting ingredients into the factory might result in price increases that would eventually be passed down to consumers.

Retailers

- There would be an immediate impact on the supply of fresh and chilled food products as they rely on frequent deliveries from suppliers.
- During the first few days of a disruption, it is expected that consumers would panic buy staple foods such as bottled water and bread. In the case of prolonged disruption, consumers would have to adapt and substitute for their product preferences based on stock availability in stores.
- They rely on their suppliers to have contingency plans for port disruptions, however, they emphasised that they have business continuity plans across all divisions for all types of risks and emergencies.

Food Service and Catering Providers

- There would be an impact on the supply of fresh produce from the EU as they rely on frequent deliveries via the port of Dover.
- Strategic measures considered by these companies include restricting sales and prioritising food supply for key customers such as hospitals and schools.
- They have the flexibility to change menus and recipes based on the product availability. Companies would also consider substituting a product or looking at alternative suppliers during prolonged disruptions.

Other Findings

a) Food Inspection
According to the FSA, the main issues to food inspection systems at alternative ports would be: different systems in practice at different ports; different facilities and shipping documentation for clearance of food products; and the lack of trained manpower required to adapt to these systems.

b) Packaging
Around 75% of the imported materials come from EU countries and another 25% from Non-EU countries. This would lead to disruptions, but usually the industry has sufficient stock for 4 to 6 weeks.

Overall, there were some commonalities found in the findings throughout the stakeholder engagement process. Fresh and chilled food products are generally indicated as the most vulnerable food products during disruptions to east coast ports. This is due to their short shelf life, the heavy reliance on imports from the EU and a
very lean supply chain practice across the food industry, which is highly dependent on constant deliveries into the UK via the ports of Dover, Immingham and the Channel Tunnel. Disruptions at the east coast ports would also have an impact on deep-sea container shipments. If all east coast ports were shut, the majority of the stakeholders indicated that they would use the Channel Tunnel as an alternative point of entry for food products from the EU. The stakeholder groups in the downstream supply chain, including food manufacturers and retailers, indicated that they would rely on their suppliers to have contingency plans in place for extreme weather scenarios. In general, all of the participating stakeholders mentioned that in the short term, they would be willing to absorb any additional costs incurred due to disruptions. However, if a disruption were prolonged, any additional costs would ultimately be passed on to the consumers. Most of the stakeholders also highlighted the fact that fuel supply disruption would cause a more significant impact to the food supply chains than an east coast tidal surge.

6. Assessment of impacts to food supplies

6.1 Scenarios

Two scenarios of east coast port disruption were designed specifically for this assessment (Table 6). A detailed discussion on the scenario design process and the difficulties/uncertainties associated with designing likely scenarios to reflect the impacts of east coast tidal surge are presented in Sub-Annex 2 of Annex 1. These were derived as reasonable worst-case scenarios, after consulting with the Met Office and the Environment Agency, and were agreed with Defra to be used for this assessment in understanding the impacts on food supplies.

<table>
<thead>
<tr>
<th>Flooding Scenario</th>
<th>Port Disrupted</th>
<th>Damage/Severity</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 1</td>
<td>All east coast ports</td>
<td>Complete inundation of ports causing closure</td>
<td>3 months</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>Some east coast ports (Humber and London ports)</td>
<td>Partial inundation and damage of ports</td>
<td>3 months; 6 weeks for RoRo berths</td>
</tr>
</tbody>
</table>

Scenario 1 is designed as a worst-case scenario wherein all the east coast ports between Tyne and Dover including Tees, Grimsby & Immingham, Hull, Felixstowe, Harwich, London and Medway are disrupted and closed for three months.

Scenario 2 is a moderate scenario wherein some of the east coast ports, namely Immingham, Hull, Harwich, London and Medway, are disrupted for the same three months except for the RoRo berths in these ports, which are assumed to be operational after 6 weeks as port operators stated that these facilities could be recovered sooner.

This section summarises the key findings of the assessment performed by analysing and modelling the shipping and port capacity for the above two scenarios.
Food imports by Freight units

The mapping of food imports to vessel types established that the majority of food commodities (66%) arrive in the UK either in RoRo accompanied or unaccompanied trailers (45%) from the EU or in containers (21%) both from the EU and Non-EU countries. The port capacity data showed that major ports handling RoRo and container vessels are located along the east coast and disruption to them will have consequences to food commodities imported by freight units. The severity of the consequences will depend upon the ports disrupted as some of them have a disproportionate share and capacity in handling specific vessel types and freight units. However, the MARS modelling analysis revealed that there are alternative ports available with the capacity and capability for the re-routing of RoRo and container vessels and thereby the food imports by freight units.

In the case of container units, for the worst-case scenario (Scenario 1) the disruption to container units could be reduced from 67% to 41%, but no less than this as there is a lack of additional alternative port capacity/capability to handle the container traffic of Felixstowe alone, and the worst-case scenario assumes the disruption of container terminals all along the east coast. If Felixstowe is not disrupted in the east coast port flooding (as in Scenario 2), then the disruption to container unit imports could be reduced to an almost negligible level (0.1%) and there would be almost no effect on food commodities shipped by containers.

For RoRo units, the analysis revealed that alternative port capacities could significantly reduce the consequences of an east coast port disruption scenario. Even for the worst-case scenario the disruption to RoRo units could be reduced by half (from 59% to 29%) by re-routing to alternative ports. This is largely due to the additional capacity being available at the Channel Tunnel to handle 50% of Dover RoRo units. However, unlike container unit imports, for which if alternative port capacity is available there will not be any disruption, RoRo units will suffer some disruption even in a moderate scenario. This is due to the loss in RoRo shipping capacity because of longer turnaround times in re-routing to alternative ports.

Food imports requiring bulk handling

The east coast port disruption scenarios, in fact both the worst-case and moderate scenarios designed for the assessment, identified that some key bulk commodities such as vegetable oils and sugar imported by east coast ports will be affected. Unlike food imports arriving by freight units, many bulk commodities can only be handled at alternative ports with the required special handling facilities for the specific commodity, even if the capacity exists for handling bulk vessels. Most bulk commodities rely on the refining or processing facilities located close by the importing ports. Even if suitable alternative ports were found for handling the diverted vessel, land transport of large volumes of such commodities to their refineries will require significant capacity and journeys by trucks and it defeats the reason why the facilities were located near the ports in the first place. Therefore, for food commodities imported in bulk, the impacts of port disruption can only be assessed by understanding individual bulk commodity supply chains and will need to take into consideration their stock levels.
Key food commodities

Supplies of pig meat and fresh produce, which are largely imported from the EU using RoRo vessels, will be disrupted in east coast port disruption scenarios. In a worst-case scenario, both these commodity imports could be disrupted by more than 60%, but if the RoRo vessels were to re-route to alternative ports then the disruption could be reduced to nearly half (33%). Even for the moderate case scenario there will be some disruption to these commodities due to the reduction in RoRo shipping capacities in re-routing to alternative ports, as reflected in the case of pig meat imports (7.1%) but fresh vegetables will be less affected, since these mainly arrive by accompanied trailers through Dover, which was assumed to be operational. Both the commodities rely to an extent on JIT practices, particularly the fresh vegetables and fresh pig meat that are imported directly to retailing shelves or with minimum buffer time and stock. Hence, these commodities will see immediate consequences to their retailing.

Regarding palm oil and sugar, which are imported in bulk, although they will be disrupted and delayed by east coast port disruptions, there will be stocks of them available and therefore the impacts will not be immediate. The bottleneck for these bulk commodities is the handling capacity/capability of them at alternative ports. In the case of palm oil, which requires heated tanks at the handling port in order for the vessels to discharge the crude oil, the availability of alternative ports with such facilities is limited and even if available there may not be sufficient capacity for storing additional volumes. However, in the case of raw cane sugar, that requires no special handling, there are alternative ports with sufficient capacity to import it. These commodities, being raw materials and basic ingredients in the manufacturing of other food products, could affect dependent products if import disruption lasts for some considerable time. In such cases, local production, (as in the case of sugar with beet) and substitution by other products (as in the case of palm oil by other vegetable oils) could be solutions to meet the demand. Some volumes of these could be imported as refined or processed products, however, this will depend on the RoRo and container shipping capacity that will already be disrupted.

7. Consumer behaviour

This section will summarise the findings of the literature review-based study carried out to investigate likely consumer behaviour in response to pressures on household food security due to natural disasters. The review specifically focussed on consumer behaviour, communications and actions of governments and companies, and social media usage during and after natural disasters, with emphasis on the impact to the supply and consumption of food and drink. The research was primarily based on selected case studies of recent major natural disasters (see Table 7), and also looked at extreme weather events in the UK and US for consumer behaviour. The case studies were selected based on the magnitude of the impact to consumers and the food industry.
### Table 7 Summary of case studies

<table>
<thead>
<tr>
<th>Country</th>
<th>City/Region</th>
<th>Date</th>
<th>Type</th>
<th>Damage estimates</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>North eastern Japan</td>
<td>11th March 2011</td>
<td>Earthquake and Tsunami</td>
<td>19,295 deaths and 359,073 houses destroyed</td>
<td>Imamura and Anawat (2012)</td>
</tr>
<tr>
<td>New Zealand</td>
<td>Christchurch</td>
<td>4th September 2010 to 22nd February 2011</td>
<td>Earthquakes</td>
<td>185 deaths and over 150,000 houses damaged</td>
<td>Parker and Steenkamp (2012)</td>
</tr>
<tr>
<td>Australia</td>
<td>Queensland and large parts of eastern Australia</td>
<td>25th December 2010 to 3rd February 2011</td>
<td>Flood</td>
<td>33 deaths and at least 70 towns and over 200,000 people were affected</td>
<td>Queensland Government, (2014) and Zhong et al. (2013)</td>
</tr>
<tr>
<td>United States</td>
<td>Gulf Coast United States</td>
<td>29th August 2005</td>
<td>Hurricane</td>
<td>2,000 deaths and 200,000 houses destroyed</td>
<td>History.com (2014) and Gill (2006)</td>
</tr>
</tbody>
</table>

The detailed findings of the review are presented in Annex 3, while the key findings are summarised below.

**Consumer behaviour**

- It was demonstrated in all four case studies that residents who live outside the affected areas tend to stockpile and become involved in panic buying. The goods that the residents tend to stockpile and choose during panic buying include bottled water, milk, bread, rice, pasta, canned foods, powdered milk and baby food. The directly affected residents opt to shop at local convenience stores instead of out of town stores. Residents in the US and Australia respectively tend to cut back on restaurant visits and to be willing to substitute products and compromise on product quality.

- Events since 2010 have revealed emerging trends in consumer behaviour. The UK Office for National Statistics (ONS) reported that local convenience stores had fared worse than large stores due to shoppers opting to buy food online rather than go to their local stores during the winter of 2013. Moreover, Japanese
consumers purchased more goods online after the earthquake and tsunami in order to avoid the ‘embarrassment’ on being seen shopping in public.

- After a natural disaster, the affected residents displayed resilience and reverted to their normal life, however, there were a few common negative psychological impacts after Hurricane Katrina and the Christchurch earthquakes, including increased purchases of alcohol, increased anxiety and stress levels and a tendency towards the consumption of unhealthy foods.

Communications and actions from major companies

- During and after a natural disaster, major companies provided coherent and regular communication on operations, recovery efforts, disrupted services and affected areas. They also displayed quick actions and continuous efforts to restore operations via various alternative sources and services.

- Major companies provided concerted efforts to restore services and operations as quickly as possible after natural disasters. For instance, in the US and New Zealand, shipping lines cooperated with other alternative ports in order to resume services and to prioritise supplies of key commodities. In Australia, retailers cooperated with each other in order to resume stock supplies to meet increased demand from consumers.

- Safety was the highest priority during and after a natural disaster. For instance, regular notices and various support were provided to staff that were affected by severely damaged working facilities. Major companies tended to prioritise overall safety at damaged facilities and infrastructures until restoration works were completed.

Communications and actions from governments

- Government departments were involved in various efforts to mitigate impacts of natural disasters. The efforts included campaigns to reduce panic buying and to encourage energy-saving efforts. They were also involved in key cargo inspection and prioritisation of supplies of key commodities.

- Education was offered to the residents on food and water related safety information by providing comprehensive guidelines on food evaluation at home and methods to minimise food and water spoilage. Moreover, the Japan Government conducted on-going tests to monitor and detect the levels of radioactivity in foods after the earthquake and tsunami.

- Various relief efforts were provided during and after natural disasters. These included the deployment of army personnel to airlift food to affected areas and the provision of financial assistance to affected farmers and producers. Government departments were also involved in energy, water and sewerage system restoration works.

Usage and role of social media

- It was evidenced that Facebook and Twitter were the most popular social media sites during and after the natural disasters in Japan, New Zealand and Australia.
• Social media sites were utilised by the affected residents, major companies and government departments to provide updates on their situation to family and friends, to provide operations updates to their customers; and to provide various recovery and safety efforts to affected residents respectively.

• The usage of social media sites has its own drawbacks in terms of accuracy and authenticity of shared updates and information. Government departments such as the Queensland Police Service and the Federal Bureau of Investigation (FBI) were involved in eliminating and dispelling rumours, misreporting and hoax websites during and after natural disasters.

8. Conclusions and Recommendations

The key findings are discussed in the below section followed by limitations leading onto overall conclusions and recommendations.

8.1 Discussion of findings

8.1.1 Food supply chain industry resilience

Supply chain practices

Food and drink supply chain practices for individual commodities varied according to shelf life, temperature requirements, consumer demand, and degree of processing required. Most fresh/chilled and perishable goods rely on JIT practice with minimum lead times from farm to shelves with just about time for consolidation and packaging. This practice relies on the fast ferry link RoRo services from the European ports and the majority of these imports come to ports along the east coast, which are nearer to the continent. The importers of these food commodities consider the Channel Tunnel as the only alternative for such products and if capacity is not sufficient they will have to face wastages and shortages. In addition, the consequences will be immediate at the retailing shelves as there will be very little stock stored for such perishable and low shelf life products. The distribution centres for these products tend to be closer to the ports offering the RoRo services. While this may not be an issue for say a Dover to Channel Tunnel diversion, it may be for food imports diverted from Humber and Haven ports to south/west coast ports and there will be delays in transport for distribution to retailers. Also, many of the processing and consolidation centres are now located in Europe and further investigation is needed to understand such dependencies and overreliance on short sea shipping and whether they offer improved or reduced resilience in the case of major port disruptions.

Food supply chain industry contingency/resilience strategies

UK food supply chains involve a wide range of organisations offering a number of different supply chains, which makes the system resilient. However, there also exist complex inter-dependencies between the stakeholders, with the result that it is difficult for them to comprehend vulnerabilities in disruption scenarios. One example is the supply of packaging materials, imported mainly through east coast ports, which would affect the safe distribution and retailing of food commodities, particularly when food imports are already delayed and disrupted. It was also recognised during the engagement process that most of the stakeholders are focussed on short term and
high probability business risks rather than on low probability higher consequence risks such as a prolonged disruption of east coast ports. While most stakeholders had some experience of minor port disruption and delays, the potential vulnerability of east coast port operations to a major tidal surge and longer term disruption was not part of their risk list and therefore they had no specific business continuity plans. Many stakeholders became aware of the threat only during our engagement process and have now started to consider strategies, while some felt the risk to all east coast ports as unrealistic.

The major east coast ports are well aware of the impacts of tidal surge and have been taking actions to minimise future disruptions. While south and west coast ports were willing to handle re-routed vessels, they do not have any plans for how to handle a sudden increase in demand, as businesses don’t tend to operate with excess capacity, and they felt the facilities and resources would not be able to cope with additional demands. While re-routing of food imports to alternative ports is the general strategy, many stakeholders considered the Channel Tunnel as the main alternative port of entry, specifically for food products with short shelf life and low inventories. Many manufacturers and retailers in general outsourced logistics and distribution to 3PLs and expected their suppliers and shipping companies to have contingency plans. Alternative sources and suppliers was mentioned as a strategy, however, most suppliers depend on the reliability of ports and shipping operations, but with disruption to capacity there would be stiff competition among manufacturers and retailers for such supplies. There were also some strategies to mitigate food supply disruption at different stages of the food supply chain, such as manufacturers and retailers being willing to accept available alternative products as substitutes, and catering service providers’ flexibility to change menus based on available food commodities, and prioritisation to key customers such as hospitals and schools. In addition, the retailers expect initial panic buying by customers of staple foods and later adaptation to substitutes, as reported in our consumer behaviour review. However, the handling of customer behaviour during a shortage of food supplies needs clear plans and communication strategies in place by retailers.

8.1.2 Government intervention/role

The food supply chain industry, particularly ports, shipping lines and logistics companies, expect the Government to have strategies in place to mitigate the impacts of such major east coast port disruptions, while the Government on the other hand expects the industry to have business continuity plans to handle the disruption and be resilient. Without Government guidelines and clear communication of priorities for such emergencies, the industry feels it is difficult to determine by itself the priorities for UK resilience while overcoming issues such as contractual obligations, capacity to meet sudden additional demand, and related competition issues among stakeholders themselves. The port and logistics companies felt that there might be a need for derogations on vehicle driving hours and food labelling. The Food Standards Agency will need plans for inspections for the diverted food imports to alternative ports that might not have the appropriate systems and required manpower to make sure food security/quality is not compromised for the speed of clearance that may be required in such scenarios. Freight transport may need to be prioritised over passenger traffic in potential bottleneck locations in order to utilise additional capacity and reduce delays in places such as ferry terminals, access
roads to ports, and critical road links. The Channel Tunnel, which will be a critical alternative port of entry for food commodities, will require its smooth running to be safeguarded by UK and French Governments, as there will be a risk of severe bottlenecks and heavily increased demand placed on it in the event of east coast port disruptions. While all stakeholders including Government agreed that food imports would need to be prioritised over other commodities, there is no clear plan as to how this can be achieved. There is very little that can be done to prioritise Non-EU imports and probably only after 2 weeks of disruption, as the importing vessels would have already departed from their origins to the UK. Even for EU Imports that arrive by trailers and containers, there are many issues such as tracking and identifying critical food commodities and in segregating them to get shipped in a single vessel. Other questions to be resolved on prioritisation include whether it has to be done at the origin of import or at the UK Port of entry, and which other imports could be held back and what will be impact on those industries etc.

In addition, most stakeholders felt that the flood defences and tidal barriers across the east coast need to be improved by the Government for the protection of ports and critical infrastructure against tidal flooding. The recent east coast tidal surge of the winter of 2013 has affected most of the flood defences, which are currently being repaired. In addition, the EA has planned for improvements to existing defences in vulnerable areas such as Humber but it may take a few years to achieve the necessary level of protection, before which there is a threat of a tidal surge recurring and the east coast ports need to be prepared for it. The Government departments, realising the role and criticality of these ports to the UK Plc, have been engaging with the operators in preparing and planning specifically for east coast tidal surges. However, the Government is yet to engage with ports from the perspective of alternative ports readiness, and capacity/capability to handle additional demand, as some ports expect the Government to support them to meet the additional demand. Also the Government needs to engage with its European counterparts as the resilience of UK systems relies upon those counterparts to operate without disruptions for east coast tidal flooding. What would happen if the major Northern European ports were disrupted in the event of a tidal surge scenario along with UK east coast ports? Would there be continued exports from EU to the UK or would those countries prioritise other customers or local consumers? These questions require investigation, and communication channels need to be put in place between the UK and its EU counterparts to mitigate the consequences of such disruptions.

### 8.1.3 East coast port/shipment criticalities

**Port of Dover/Channel Tunnel**

Both the data established and the engagement with food supply chain stakeholders clearly showed Dover to be the key port of entry as far as food imports to the UK are concerned. It handles more than a quarter of EU food imports and, more importantly, the majority of them are perishable/fresh commodities that rely on JIT practices. Dover’s short sea fast ferry services rely on specialised berths with shore based ramps that are specifically designed to facilitate quick turnaround times and thereby the capacity for significant numbers of trucks/trailers that are transported from and to the EU. If the port of Dover were to be disrupted by an east coast tidal surge, this specialised service along with a significant shipping capacity between the UK and the EU would be lost. While Portsmouth was suggested as an alternative with a
single berth that could accommodate Dover vessels, it is neither a favourable option (due to the significant increase in the distance and journey time for drivers and the reduction in capacity) nor a suitable option as it was confirmed later by Portsmouth that the capability to handle Dover ferries doesn’t exist with them anymore. There is no alternative commercial port that currently exists on the south coast to serve these specialised vessels.

The only option for these accompanied trailers would be the Channel Tunnel shuttle service. However, the capacity of the Tunnel to handle all of the Dover – Calais/Dunkerque traffic is something that needs further investigation. Our desktop analysis of the design capacity of the Channel Tunnel service revealed that it could accommodate as much as 80% of Dover traffic but the stakeholders’ feedback was that this would not be possible due to operational constraints and would need significant co-operation on either side of traffic management operations, particularly car passenger traffic. Nevertheless, this backup capacity is crucial for longer term Dover disruptions and needs to be studied in depth and planned as a contingency measure involving all the stakeholders. Other options are alternative ferry routes, such as the ones serving Portsmouth, which could take a portion of Dover traffic if trucks were diverted to Le Havre, Caen etc., but the delays would have to be managed for this additional distance and journey time.

**Container ports/shipments**

The east coast ports account for a major share (more than 65%) of handling the container shipments to the UK. Our analysis clearly showed that if these container terminals were disrupted, there would be limited capacity elsewhere in the UK to handle the volume. Felixstowe alone handles more than 40% of container units served by some of the largest vessels. If Felixstowe were to be disrupted by an east coast tidal surge there would be significant disruptions to container traffic, as the only alternative port that could handle its vessels would be Southampton and possibly some at Liverpool. While Southampton could handle a certain proportion, there would still be significant numbers that could not be served in the UK, as reported in our analysis, as many of these container vessels would opt for unloading their containers in the continental ports if the delay were to be increased due to lack of capacity for larger vessels. The other alternatives, such as the terminals in London, including the newly developed London Gateway that offers significant capacity/capability for deep-sea vessels, cannot be considered as backups for an east coast tidal flooding scenario as they may also be disrupted. In the future, Liverpool 2, the new container terminal under development and due to be operational by winter 2015, will offer capacity/capability to handle larger deep-sea vessels and could offer the most needed resilience in UK container port capacity for east coast port disruptions.

In the meantime, plans need to be prepared for bringing back the containers that would be unloaded in the EU ports such as Le Havre, if Felixstowe were to be disrupted. One proposed solution was to run dedicated short sea container vessels between these ports and south/west coast container terminals, which could be achieved by moving disrupted short sea container vessels on the east coast. Also, some of the containers could be transferred to unaccompanied trailers to utilize the existing RoRo spare capacity in the south/west coast operations. The ports of
Southampton and Liverpool will need to be prepared to handle the significant additional number of container vessels that would be diverted from the east coast, as there may be a shortage of land-side space for storing containers, particularly empty ones and the ones requiring reefer points etc, and the manpower/resources need to be managed efficiently.

RoRo ports/shipments

Other than Dover in the east coast that handles accompanied trailers, a number of ports such as Immingham, London, Medway, Harwich, Hull etc. handle significant volumes of RoRo unaccompanied trailers. These would be disrupted in an east port disruption scenario. Although the RoRo vessels could be diverted to alternative ports and the handling of these are not specialised, the diversion of short sea RoRo traffic is not simple. Most RoRo operations are scheduled regular services between specific ports on the continent and the UK and are organised to balance with journey time, terminal resources/facilities, vessel numbers based on demand for the route etc. If these were to be re-routed suddenly, all of the above would be affected and operators’ feedback is that the demand for their service would change significantly due to reduction in capacity. Our analysis showed that, if east coast RoRo berths were affected, the nearest options in the south are only New Haven, Portsmouth and Southampton, which are significantly farther. One additional solution that came to view in the analysis is the diversion of northeast RoRo services to terminals in Scotland (Forth), if they remain operational in the event of an east coast tidal surge. These alternative ports are far from the usual east coast RoRo operations and imports by unaccompanied trailer units will suffer significant reduction in capacity. The shipping operators think that some of their clients would shift to alternative routes and accompanied trailers and compete for capacity along the south including the Channel Tunnel. In any case, there would be disruptions to imports shipped in RoRo units during an east coast port disruption scenario and planning would be needed to prioritise food imports for bottlenecks in utilising the alternative RoRo route capacities.

Bulk cargo handling/shipments

Our study showed that bulk cargo imports, specifically palm oil and sugar may be affected by east coast port disruptions. For bulk commodities that require special handling and storage, such as palm oil, there are limited alternatives for re-routing, while for the ones that don’t require any special handling, such as sugar, there exist adequate alternatives. Even if capacity/capability exists for diverting these imports most bulk commodity imports are raw ingredients and need transporting to their refining processing plants that are located close to their disrupted terminals. These plants are located near the terminal in order to avoid this inefficient bulk volume transport by land. Further investigation needs to be carried out to determine if the refineries/processing plants that are closely located to east coast ports would be vulnerable to tidal flooding. The alternative solution for bulk food import disruptions is to import the refined products from Europe using short sea RoRo or container vessels, which again in an east coast port disruption scenario would lack the capacity to handle even their usual demand. However, stocks for these bulk commodities would be available, in contrast to perishables/fresh imports, and the consequences will not be immediate. The subject of individual bulk food commodity
supplies, if identified as critical in the case of longer term port disruptions, requires further investigation and the overcoming of commercial confidentialities. Plans need to be agreed upon, taking into consideration alternative refining capacity offered by competitors, local production capacity and substitution options to mitigate any shortage of supply.

8.2 Challenges and Limitations

The following are the challenges and limitations of the stakeholder engagement process and findings:

- The study established data on ports of entry and the shipping modes for UK food imports that relied on best estimates for EU food commodity imports and a mapping of food commodity imports to certain vessel types for which data was not available. The estimates were derived at an aggregate level of food commodity imports which when analysed at disaggregate levels had to deal with some anomalies, particularly when assessments were carried out for some selected key commodities. Estimating at detailed levels for every individual food commodity would be ideal, but this will be impossible unless they are recorded in the first place.

- Information on business strategies and continuity planning are considered confidential by some stakeholders and were less willing to share. The worst-case east coast port disruption scenario was seen by some as unlikely, while others treated it as a 'threat' to their business, and feared that any shared information would be perceived as a weakness in their current operating model.

- The east coast port disruption scenarios designed for the assessments were primarily aimed at understanding the impacts on food supplies and thereby establishing baselines that could help prepare plans and policies for recovering from the worst scenario. There is no plausible way to design the most likely scenario for an east coast tidal surge and its impacts, as there are a number of uncertainties involved in their prediction.

- The assessments that relied on the MARS model were optimistic outcomes based on ideally expected behaviour of shipping and port operators who had complete information on the disruption scenario as well as on available alternative capacities. In reality, this may not be the case and many of the stakeholder actions could be based on incomplete information and would depend on contractual obligations, competitor actions, customer demand, existing relationships and preferences, established practices etc., which are difficult to capture, model and analyse.

- The assessment did not take into account the impacts of an east coast tidal surge on European ports and assumed that they would remain operational and shipments from Europe would not be affected.

- The impacts of east coast port disruption on fuel and energy supplies has not been investigated. The disruption of these vital supplies for food supply chain industry functions could significantly exacerbate the food supply disruptions and many stakeholders were more concerned about these supplies.
• The likely consumer behaviour and the actions by industry and the Government to mitigate the situation during and after natural disasters are based solely on previous findings from academic literatures, reports and online information. The research was based primarily on case studies of disaster events from different countries and the findings may not be directly applicable to the UK context.

8.3 Conclusions

The aim of this research was to examine the effects of a potential coastal flooding event, which could severely impact on the capacity of east coast ports, and to inform Defra and the food supply chain industry about what factors they should consider to prepare for and respond to the incident in order to maintain the security of supply chains and household food security.

In order to examine the impacts on food supply, the project first established the ports of entry for food commodity imports from the Non-EU and derived best estimates for EU imports. This made it possible to determine the key food importing ports, the share and criticality of east coast ports and the food commodities handled by them. The data established Dover along with the Channel Tunnel as the most critical east coast ports of entry as far as food imports are concerned, this was also confirmed by the stakeholders who participated in the project. A disruption to Dover would have more impacts than to any other port on the east coast due to the specialised fast ferry links it serves from Europe that provide the JIT supplies for perishable short shelf life food products, particularly fresh and chilled food imports. The Channel Tunnel would be the only back-up for Dover and would have the potential capacity to significantly reduce disruption, if all its capacity were utilised efficiently. The other critical ports would be Felixstowe, serving the biggest container vessels for Non-EU food imports, while London and Hull serve critical bulk commodities such as sugar and palm oil, and Immingham handles unaccompanied trailers and EU meat imports.

If a major tidal surge were to disrupt all the east coast port operations for some months, then there would be disruption to food supplies imported by UK ports and the degree of disruption would vary according to the food commodity type and the shipment method. If they were to arrive in containers or RoRo trailers, the assessment of an alternative port of shipping capacity analysis revealed that potentially half the disruption could be reduced by utilising re-routing optimally. There would be disruption and delays to bulk commodity food imports in longer term disruptions however, the stock levels along with production and substitution possibilities could help mitigate consequences. The food supply chain stakeholders engaged were willing to utilise all the capacity available to mitigate disruption, but many felt that disruption of this nature would need some strategies and guidelines from the Government. Particularly there was a need for clear priorities to be set for food commodities by the Government, as it was felt to be difficult for the industries themselves to cope, considering contractual obligations, competition and the lack of capacity to meet consumer demand. The study also identified from stakeholders that there are significant opportunities down the supply chain order i.e. at the retailing and catering industry level to mitigate food supply disruption using substitution of other available food commodities.

The study also reviewed consumer behaviour during and after natural disasters that offered evidence of the likely behaviour of consumers, including stockpiling and
panic buying, and their ability to adapt to substitute products. The review also presented the response actions in mitigating impacts, and the emerging role of social media as a key communication platform for both the industry and Government in offering updated information to consumers.

8.4 Recommendations

- More engagement with the food supply chain industry is required to make key stakeholders aware of the system wide consequences and their interdependent vulnerabilities in the event of longer term port/food supply disruptions with an emphasis on the criticality of business continuity plans for such scenarios. Periodic workshops/exercises involving critical food supply chain stakeholders to discuss such low probability high impact risks will improve awareness and visibility of the interdependent risks.

- There are possibilities at the manufacturing, retailing and catering end of the supply chain to mitigate food supply disruptions including substitution and prioritisation strategies. This requires investigation beyond the limitations of commercial confidentialities and more work is needed at individual commodity flow levels to understand their contribution to the finished products to ensure consumer availability.

- UK food suppliers’ dependence on EU refining, processing and consolidation centres leading to reliance on the reliability of short sea shipping, needs further investigation. Short sea re-routing possibilities, where available, will require further exploration and engagement with the importers, shipping agents and the freight forwarders as the RoRo services will have to work in response to these stakeholders’ business demands.

- While 3PLs are well positioned and flexible to cope with re-routed shipments, the implications of the new EU driver regulations need further exploration regarding the demands placed on drivers during major port disruption scenarios.

- Government role and support is expected by port operators, shipping lines and 3PLs in the following areas:
  - Guidelines and clear communication of priorities for critical commodities and shipments, as the industry by itself cannot overcome issues relating to contractual obligations, competition and sudden capacity needs.
  - Derogations for drivers’ working hours and food labelling.
  - Priority of freight movement over passenger transport and actions to reduce bottlenecks at critical ports of entries.
  - Improving flood defences and tidal barriers to protect east coast ports and critical infrastructure.

- Both Government and Industry need to engage more with their European counterparts to understand actions and communications required in the event of major east coast tidal surge, which may equally affect the Northern European
ports along with UK east coast ports that could exacerbate food supply disruptions.

- The Food Standards Agency will need plans for the increased demand that will be placed on inspections for the diverted food imports at alternative ports to make sure food security/quality is balanced with the speed of clearance that may be required in such scenarios.

- The Met Office/Environment agency and ports should work together to understand the specific flood risk information, both longer term forecasts and immediate warnings, that could be communicated and required by ports which will enable them to plan infrastructure for future resilience and also develop appropriate short term emergency response actions.

- Work needs to be commissioned on the impacts of east coast port disruptions on fuel supplies and food packaging material imports, as these are critical dependencies for the food supply chain industry functions.

- Data on UK and European port capacity/capability from the perspective of emergency management and response should be gathered and made available for analysis and contingency planning. Mechanisms to record details of the port of entry data for EU goods and their shipment modes need to be in place for more accurate analysis of port disruption consequences and to plan response actions.

- Dover and the Channel Tunnel are critical routes of entry for UK food imports and their resilience and capacity to back each other up for a longer term disruption should be studied further as an inter-dependent system. The stakeholders involved in maintaining this crucial link between UK and EU need to be engaged, made aware of the consequences, and their cooperation on joint resilience plans for disruptions is vital. In addition, possibilities of developing capacities at alternative ports/routes of entry for the accompanied trailers using Dover/Channel tunnel needs to be explored as a contingency plan.

- The UK deep-sea container service will require the European container port transhipment capacity to compensate for a major east coast port disruption, particularly in the case of Felixstowe. This needs further analysis to understand the sort of dedicated short sea shipping capacity required for transhipment and to establish if this will be available.

- Alternative key ports of entry such as Southampton, Liverpool, Portsmouth and Forth should be engaged and verified regarding their readiness to cope with the additional demand and to plan the support actions needed to improve and utilise their capacity efficiently. Scenario planning exercises involving major ports and shipping companies are recommended as part of the engagement.

- Understanding likely consumer behaviour is crucial in managing the demand during disruption to food supplies. More work is needed in the UK context in the form of case studies involving different population groups to understand their responses to pressures on food availability and to recommend priority actions by the food industry and the Government in such scenarios.