Study on Blue Growth and Maritime Policy within the EU North Sea Region and the English Channel

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Annex III G - Sector Analysis – Coastal Protection

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1 Analysis of coastal protection sector in the North Sea and the English Channel

1.1 Introduction: coastal protection in the North Sea

The Norwegian coast is a fjordic coast, and much less sensitive to erosion than the coasts of most other North Sea countries, also because land areas are on average located substantially above MSL. The country does however experience the highest wave heights and lower areas are thus susceptible to flooding. Especially smaller and remotely located areas may be vulnerable, while also key infrastructure near the coast may be affected by sea level rise, in particular on the Western coast of the country.[1]

The UK coast is most susceptible to erosion on the south side (chalk cliffs), with four of the top-10 erosion sites located there, two others on the east coast and the remainder on the Atlantic side.[2] Contrary to the problems faced on the continental side, the erosion of the coastline is a major problem faced, as shown in the photo below.

Figure 1.1 **The eroding coast at Happisburgh in Norfolk (Photo: © Mike Page)[3]**

Flooding risks in the UK are highest on the east coast.[4] Besides government measures to reduce flooding risks, private property owners are also encourages to take measures to reduce flood impacts, and a flood insurance scheme is introduced for high risk areas.

In the Netherlands more than 85% of the coastal zones is located below 5 metres elevation, which makes the sandy coast highly vulnerable. The safety of the Netherlands is dependent on reliable flood protection structures[5]. Natural sand dunes and human-made dikes, dams and floodgates provide defence against storm surges from the sea.

Belgium has a coastline of 67 km bordering the south-eastern part of the North Sea. The entire coastline is situated within one province, West-Vlaanderen. The influence of the North Sea is observed in some important Belgian cities like Ghent and Antwerp. Coastal protection measures such as beach nourishments and the maintenance of coastal defence infrastructures are carried out

[1] http://www.climateadaptation.eu/norway/coastal-erosion/
[2] http://www.virginmedia.com/digital/science/pictures/coastal-hotspots.php
[3] http://www.bgs.ac.uk/landslides/happisburgh.html
[4] Environment Agency, 2013, Managing flood and coastal erosion risks in England: 1 April 2012 to 31 March 2013
[5] http://ec.europa.eu/maritimeaffairs/documentation/studies/documents/netherlands_climate_change_en.pdf

every year. The general tendency in the coastal defence policy in Belgium is to use soft measures, mainly beach nourishments, to safeguard the natural dynamics of the coast[6].

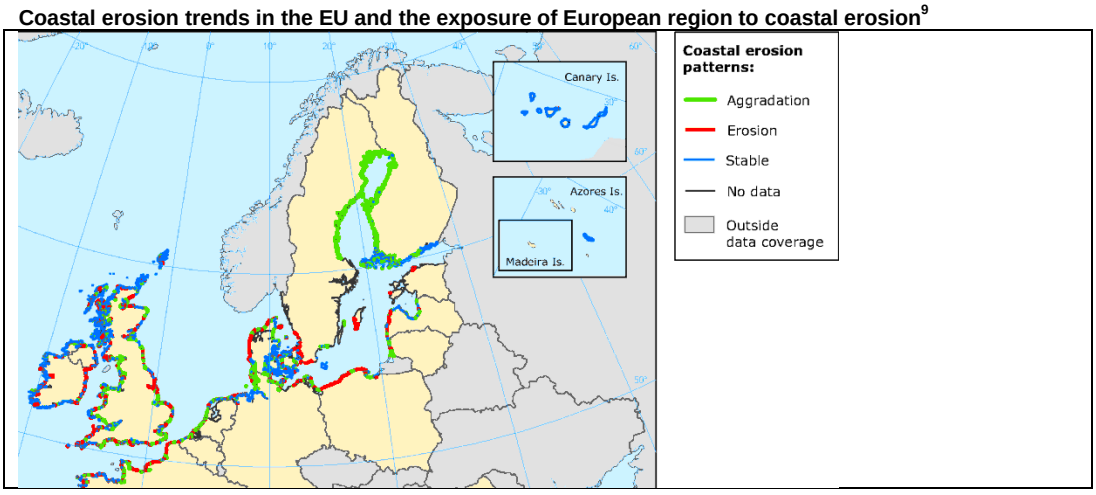
The German coastline along the North sea is mainly shallow, i.e., marsh, dune coast, or beach wall. Recent coastal morphological investigations have shown that approximately 75% of all (sandy) coasts are subject to erosion. Coastal protection measures are both soft (beach nourishments) and hard.[7].

Denmark's vulnerability to coastal flooding and erosion is rather limited. Although the Danish North Sea coast is more exposed to sea level rise and storm surges than the eastern part of the country, flooding and erosion are not considered to pose a real threat as low-lying coastal areas are often farmland or land with few inhabitants. An exemption is the west coast of Jutland which is most exposed to the North Sea waves and vulnerable to coastal erosion. The measures carried out are mainly sand nourishments, but also dune protection and revetments takes place[8].

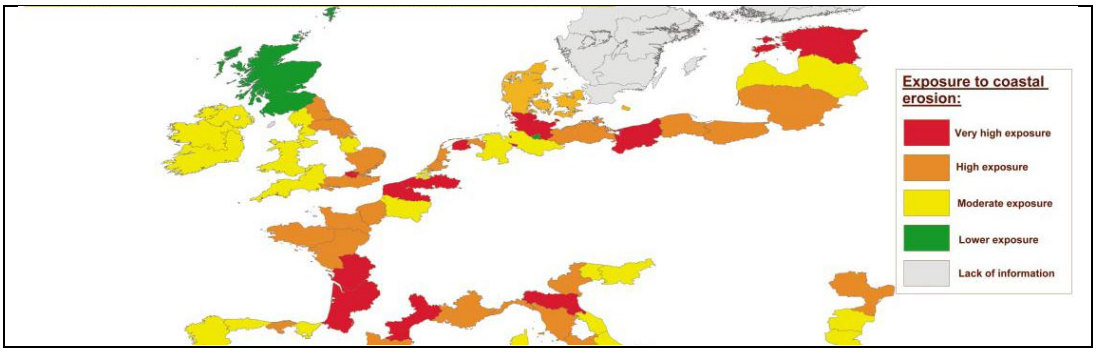
In France the North Sea region Nord-Pas-de-Calais is considered as one of the most vulnerable to erosion in France. The coast of this region largely consists of wide sandy beaches and coastal dunes, locally interrupted by estuaries, coastal settlements and some rocky cliffs. Over 50% of the coastline is receding. By law, private property owners are responsible for coastal protection measures.

As can be concluded from above and can be seen in the map below, coastal erosion patterns and the need for coastal protection differs per North Sea region.

Figure 1.2 **Coastal erosion trends in the EU and the exposure of European region to coastal erosion[9]**



6 http://ec.europa.eu/maritimeaffairs/documentation/studies/documents/belgium_climate_change_en.pdf
7 http://www.climateadaptation.eu/germany/coastal-erosion/
8 http://ec.europa.eu/maritimeaffairs/documentation/studies/documents/denmark_climate_change_en.pdf
9 http://www.eea.europa.eu and http://www.eurosion.org



1.2 Economic performance of the sector

The onset of the industrial revolution resulted in a much higher demand for the benefits of a coastal location. However, this development was increasingly threatened by the natural erosion and flooding processes of the coastal environment. To deal with the threat new engineering technologies were used to create coastal defences. Coastal defence can be seen as the catalyst for all kinds of marine activities such as dredging, coastal development, land reclamation, port development, offshore techniques (offshore energy, deep sea mining).

While in the country fiches the sector of water projects (NACE 42.91) was taken separately from all other marine functions, here we start the analysis from the coastal protection *function*, as this is considered a key driver for the water sector to prosper and to be able to expand to other marine functions.

Coastal protection is not an economic function in itself, but rather a conditio sine qua non for the use of coastal areas and for allowing other economic functions to flourish. Coastal protection can be distinguished in three main maritime economic activities:

- Protection against flooding and erosion: Monitoring, maintaining and improving the protection of coastal regions against flooding and erosion;
- Preventing salt water intrusion: Measures associated with coastal protection works aiming at the prevention of salt water intrusion as a measure to protect fresh water functions in coastal regions;
- Protection of habitats: Measures associated with coastal protection works aiming at protecting natural habitats.

The sector generates GVA and employment through the implementation of flood and erosion protection infrastructure. The following table shows the GVA and employment the North Sea and English Channel. Specific basin information is not available for France and the UK.

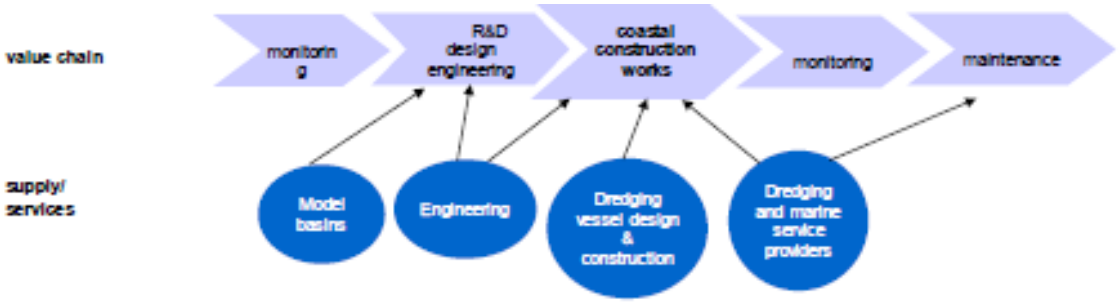
Country	GVA (€, m)	Employment (x 1,000)
Norway	N/A	N/A
Denmark (Baltic and North Sea)	305	1.42
Germany (North Sea)	11	1.13
Netherlands (including construction of water projects)	627	5.20
Belgium	460	3.52
France (North Sea, Atlantic Sea and Mediterranean sea)	12	0.118
UK	*	*

Source: country fiches - * Data not available

Although the above figures are fairly small compared to some other marine sectors, the economic relevance of this function is still substantial since it enables other maritime economic activities or results in a higher economic value of the economic activities in the coastal area. The implementation of flood protection measures allows, for instance an increase in: population, tourism development, land and property values, industrial development, agricultural potential, income levels etc. Furthermore there may be substantial spill-over effects from coastal protection to other marine sectors, e.g. by providing technologies to develop infrastructures or other services.

1.3 Value chain

The sectors within this economic activity that are part of the value chain are monitoring the risk of flooding and erosion, design the coastal protection measures, construction of these measures, monitoring again, and maintenance of the structures in order to guarantee the required protection level. Whereas in the monitoring and design, both government agencies and engineering firms are the main players, construction is led by four large dredging and marine contractor firms (Boskalis, DEME, Jan de Nul and Van Oord). Coastal protection is not only about dredging. Storm surge barriers in The Netherlands (Oosterschelde kering, Maaslandt kering) in the UK (Thames barrier), and Germany (Eider barrier) and other hard flood protection have been implemented by large marine contracting firms. On the supplier industry side, IHC for instance is the leading shipbuilder in this field worldwide and VostaLMG a leading engineering and contracting company, serving the dredging industry.. At the research side, leading bodies are research institutes like Deltares, Hydraulic Research Wallingford and Danish Hydraulic Institute, along with a number of universities.



While the value chain picture in fact describes the coastal protection processes, the main economic sectors relevant to his MEA are depicted under the supply/services. The companies active in this block are also the ones providing services to many other marine sectors (e.g. port construction, land reclamation for tourism activities, offshore structures, etc.).

Innovation at IHC

IHC is the global market leader for dredging and mining vessels and equipment and supplier of innovative ships and supplies for offshore construction. More than 100 years ago, IHC shipyard built the first trailing suction hopper dredger. Since then, the group has developed many efficient, innovative and cost-effective, self-

propelled custom-built trailing suction hopper dredgers. These vessels are built according to the specific requirements of individual customers and to meet the challenges of particular projects. They can be used to: construct harbours, access and maintain deep channels, enable offshore pipeline trenching, extract sand from the seabed to reconstruct shorelines and beaches and create new islands[10].

1.4 Environmental and social impacts in the North Sea region

Environmental impact

The environmental impacts of coastal protection activities in the North Sea should be seen in the context of the morphology of the North Sea (shallow, sandy sea bed, high diversity of species) and the fact that at the same time the North Sea is a heavily used sea basin, with several major ports, busy shipping lanes, intensive fisheries activities, oil & gas exploitation, wind parks, ports and designated defence as well as nature areas. This implies coastal protection works, and the associated activities in the sea itself – notably the mining of sand for coastal suppletion – have to take place in a densely used sea space, with limitations on the operational efficiency as well as the sustainability of the practices. Furthermore the same mining of sand is also done to support these other functions (think of the expansion of Maasvlakte II in Rotterdam).

Sand mining considerations via-a-vis other functions

Sand mining in the North Sea has competition from other sea space asking sectors like for instance wind farms, oil and gas sector, sea shipping and cables. All these sectors ask for sea space in which there is no room for sand mining. Furthermore, nature claims a part of the North Sea. Areas designated as Natura2000 sites are not accessible for other functions. The same goes for areas with archaeological and/or cultural historical value or in areas in which ammunition is present. So far, sand mining in The Netherlands did not result in conflicts between other functions, but the use of the North Sea will significantly increase in the future. Conflict of interest are expected which will impact the availability of sand and costs of sand mining.[11]

The environmental impacts of coastal protection are closely related to the different techniques used and hard and soft defence measures implemented. Coastal protection can have the following negative environmental impact[12]:

- The main adverse environmental impacts beach nourishment (soft measure) impacts both at the borrow site (the sediment source) and the target site. At the borrow site removal of sediments causes damage and mortality to the benthos. At the target site, burial and smothering occur. This causes mortality to any benthos not able to move through the covering sediments;
- The conversion of coastal into artificial areas (hard measures e.g. harbours, dykes, groyne fields, seawalls, marinas, artificial beaches and other artificial constructions such as dams or sea walls) is high in certain coastal areas, such as the Belgian and Dutch North Sea coast. Due to the irreversible nature of land cover change from natural to urban and infrastructure development, these changes are seen as one of the main threats to the sustainability of coastal zones. Artificial coastal constructions may also cause loss or direct damage to natural habitats,

[10] http://www.ihcmerwede.com/dredging/innovative-vessels/trailing-suction-hopper-dredgers/

[11] Ecorys, Deltares, Aveco de Bondt (2011), Strategie planmatige zandwinning: belangenafweging en instrumentarium (strategy for planning sand mining: weighing stakeholder positions and instruments).

[12] Ecorys, Deltares, Oceanic, 2011. Blue Growth, Scenarios and Drivers for Sustainable Growth from the Oceans, Seas and Coasts, Maritime Sub-function Profile Report Coastal Protection (5.1)
OSPAR commission, 2009. Assessment of the impact of coastal defence structures

form barriers to migrating species, and changes to the wave exposure. This may alter the physical nature of the seabed, which in turn may cause erosion, sedimentation and physical and chemical disturbance of ecosystems;

- While the structures are under development there may be local loss and disturbance of natural sedimentary habitats, including the associated assemblages of animals and plants. Furthermore, there can be some local, temporal disturbance to birds and fishes, particularly from noise and vibration associated with the construction.

In the last years, the interest in measures that pay attention to the ecosystem has increased. Also the interest in using the ecosystem service is rising. Marine and coastal ecosystems are generally recognised as providing protection to flooding and erosion[13].

Social impact

Flood protection generates direct and indirect employment: direct employment as a result of the investments (dredging etc.) and indirect employment because of the economic impact of flood protection, it allows other economic sectors to develop in coastal areas.

1.5 Competitiveness

Coastal protection is a worldwide issue. Several countries in the North Sea and English Channel basin host well advanced research institutes, engineering firms as well as marine contractors, manufacturers and suppliers. They have a long history of coastal protection activities, providing high skills level and top players in executing works, both within Europe and as an export product. The region can promote this as a selling point and increases its' global competitive position which could result in growth. Massive efforts in research and technological development are made to improve sustainable and safe coastal regions, which also contribute to coastal protection works and services as an EU export product.

The strong position in coastal protection of North Sea based marine contractors has also provided them a supplier position towards other sectors within the region and elsewhere. For instance the large dredging companies in the North Sea basin expanded their core business to other offshore activities like offshore oil and gas, offshore wind energy, hydraulic engineering, towing services, salvage, mineral mining. Furthermore the sector plays a leading role in coastal protection activities worldwide (see Katrina and Sandy aftermath in the US, or involvement in Bangladesh, various African Countries and Indonesia).

However, a threat for the European competitive position – especially when it comes to providing services in other parts of the world – is an increasing competition from companies outside Europe who offer lower prices. Since public tenders more and more focus on price instead of quality, European contractors (who focus on value for money) have difficulties to match the financial offers from competitors.

1.6 Strengths and weaknesses

Strengths:

[13] Mangos, A. et al,, 2010. The economic value of sustainable benefits from the Mediterranean marine ecosystem.

- Long history of coastal protection activities, providing high skills level and top players in executing works, both within Europe and as an export product;
- Strong in design/engineering and advisory capacity. Engineering companies are working world wide;
- Well experienced contractors;
- Excellent education and knowledge infrastructure available (universities/knowledge institutes);
- Available techniques and knowledge allow a design that takes the impacts on other functions and on eco-systems into account. In addition, the knowledge to use ecosystems' natural processes for realising protection measures (one of the eco-system services).

Weaknesses:

- Coastal protection is liable to political priorities;
- Ineffective governance of coastal zones. Long and tedious planning procedures;
- High capital investments required for developing equipment;
- Since the financial crisis (2008) it is more and more difficult to get long term credits for these investments[14];
- Integrated solutions are needed in coastal areas. Knowledge is fragmented and cooperation within one cluster needs to be improved[15].

[14] Boskalis

[15] Panteia, Blue Economy (2010), Het Nederlandse Deltatechnologie-cluster, economische waarde, internationale, concurrentiekracht en arbeidsmarktperspectieven
Ecorys, Deltares, Oceanic, 2011. Blue Growth, Scenarios and Drivers for Sustainable Growth from the Oceans, Seas and Coasts, Maritime Sub-function Profile Report Coastal Protection (5.1)

2 Potential to achieve measurable BG outcomes

2.1 External drivers and factors

The core driver of growth of the flood protection sector is the actual flood risk in coastal areas. Whether or not this will lead to growth in the sector depends on the amount of urgency given to the issue of flood protection (perceived flood risk). More urgency will of course lead to higher flood protection budgets and growth of the sector. So prospects concerning the growth of the sector will depend mainly on the actual flood risk and perceived flood risk. Furthermore, flood risk is ideally addressed in an economically optimal way. This suggests that the costs of flood protection measures strongly influence the amount of measures undertaken.

Actual flood risk

Flood risk is defined as probability * damage. Therefore, changes in actual flood risk can manifest in two ways: 1) flood probability can increase as a result of climate change. This is caused by sea level rise and an increase of extreme weather events due to higher temperatures. 2) Flood damages can increase (or decrease) as a result of changes in the value of flood-prone assets. An example of a decrease in flood damage is flood resilient building or organizing hazard responses.

In the case of the Netherlands, De Moel (2012)[16] concludes that flood risks will likely increase in the future, mostly as a result of changes in the value of flood prone assets. Drivers for these changes can be manifold, though the main driver for this is economic growth. Consequently, it can be expected that (growth of) the flood protection sector is strongly correlated to economic growth.

Based on the above, the following drivers for actual flood risk can be identified:

- **Climate change**, positively correlated to sector growth;
- **Economic growth**, positively correlated with sector growth;
- Development of **flood resilient land use**, negatively correlated with sector growth;
- **Organizing Flood hazard responses**, negatively correlated with sector growth.

Perceived flood risk

The urgency given to flood protection determines the amount of investment in flood protection and consequently strongly influences growth of the sector. The following factors were identified as the major drivers for perceived flood risk:

1. Amount and scale of (recent) **historic events** of (near) flood. Frequent flood events will keep flood protection high on the political agenda;
2. **Economic growth**. The economy influences government budgets, where more lenient budgets will enable more investment in flood protection. Because economic growth also affects actual flood risk, the correlation between the growth of the flood protection sector and economic growth is further strengthened;
3. **Monitoring**. More convincing factual evidence concerning the actual flood risk will encourage investments in flood protection;
4. Flood protection **legislation**. Legislation can encourage and/or force the government to pay attention to flood risk.

[16] De Moel (2012), Uncertainty in flood risk, dissertation VU University Amsterdam.

Costs of measures versus available budgets

The costs of measures for flood protection determine the optimal level of flood protection. Lower costs for measures will, on the long term, lead to an increase in the amount (not necessarily turnover or production value) of flood protection measures. The identified main drivers for costs of measures are:

- **Oil price**. As dredging forms a large part of the type of work in flood protection, the fuel price plays a significant role in total costs of flood protection;
- **Innovations** / cost efficiencies (upstream the supply chain);
- Conflicting interests / **scarcity** of land and/or water (influencing for example the sand price having an impact on sand suppletion).

2.2 Opportunities and threats

The external drivers and factors as identified above lead to opportunities and threats for the future development of the coastal protection sector. Below, these opportunities and threats are listed.

Opportunities:

- **Growing global market** as a result of economic growth and climate change. Economic growth and climate changes increases flood risk, which is a global opportunity for the sector, with emphasis on the quickly developing and flood prone Asian market;
- Enhancing **innovation**: improving efficiency and spin-off opportunities in coastal protection. This opportunity consists of a wide range of 'sub-opportunities':
  - Multifunctional coastal protection measures. Moving from the singular dike towards multifunctional land use, leading to decreased costs attributed to flood protection and increased landscape valuation. Specialization in recognizing these synergies will enhance the sector competitiveness;
  - Multidisciplinary coastal protection sector. Linked to the opportunity above, the sector will become an integrated sector comprising of engineering as well as spatial planning, urban / socio-economic development, energy production, environmental management, etc. Players in the sector who embrace this concept will attain a competitive advantage.;
  - Shift from a probability towards a damage approach. Flood risk can be substantially reduced by taking measures aimed at reducing flood damages. On the one hand, this can focus on (flood) hazard responses, on the other land use can be designed in a more flood resilient manner;
- Growing **awareness of actual flood risk** as a result of data and knowledge availability, climate change and legislation.

Threats:

- Limited budgets for flood protection investments. This can lead to **lower demand**, despite growing flood risks;
- **Competition** from Asia, mostly based on low prices, for example for dredging or engineering works;
- Increasing lack of qualified technical operational **personnel**[17]. This can lead to higher costs of labour and/or leakage of employment towards non-European areas;
- **Fragmentation** of knowledge and expertise. This threat is strongly linked with the identified multifunctional / multidisciplinary opportunities, which pose the sector the challenge of integrating knowledge and expertise which is currently mainly fragmented.

[17] Innovation analysis water - water innovation: analysis and challenges (interdepartmental work group water innovation)

Because of the growing market and flood risk awareness the export potential grows. This potential can be utilized by maintaining a strong competitive position. The competitive position is strengthened by continuous innovations. On the other hand the relative production costs will increase, due to price competition from Asian companies and shortage of personnel with the required expertise.

2.3 Response of the sector

2.3.1 Opportunities

The sector is expectedly able to adequately respond to increases in demand. Innovations are currently being developed within the flood protection sector. This suggests that these opportunities are currently being seized. Below, recent innovations in the coastal protection sector are listed.

Whether or not opportunities relating to increased awareness of flood risks (which bridge the gap between actual and perceived flood risk) arise mainly depends on external drivers. A few examples are public debate about flood safety or climate change, recent flood events which put flood risk management on the political agenda, etc. There are, however, possibilities to actively stimulate flood risk awareness. This can be achieved by knowledge and data development, which can lead to more certainty in estimating flood risks, steering public debate in favour of flood risk management.

Examples of innovations and spill-overs

- Coastal Change Pathfinder Programme (UK)[18]
  This project commissioned over fifteen pilot projects to assess how to economically address coastal change issues. These projects were evaluated, to utilize lessons learned and assess how the projects could be used in other coastal adaptation settings in England. Amongst other activities, innovative solutions focused on accepting damage instead of preventing coastal erosion were assessed (evaluating what kind of payment scheme is optimal, e.g. “Rollback” and “Buy and Lease Back”).
- Digital Delta (Netherlands)[19]
  Developing publically available data in a useable format to allow flood protection managers as well as researchers to more efficiently and reliably design and develop measures. This innovation has significant spill-over potential, as it can be utilized in all marine sectors which require (marine) data.
- Chain of safety (EU – North Sea region[20]) and follow-up projects (Germany, Denmark[21])Contingency planning, improving emergency responses and flood impact. Potential spill-over: the high data (management) requirements for contingency planning can potentially supply data as well as improve production efficiency through data processing for marine sectors.
- Energy producing flood barriers (Netherlands)[22]
  Studying the possibility of producing energy with kinetic wave energy, which would also protect the flood barrier from wave impacts.
- DEFRA and Environment Agency Flood and Coastal Erosion Risk Management (FCERM) research and development programme (UK)[23]

[18] https://www.gov.uk/government/policies/reducing-the-threats-of-flooding-and-coastal-change
[19] http://www.digitaledelta.nl/
[20] http://www.chainofsafety.com/
[21] http://eng.kyst.dk/storm-surge-warning-management.html
[22] http://www.innoverenmetwater.nl/upload/documents/De%20energieproducerende%20duurzame%20dijk%20(rapport).pdf

Focus on valorization of knowledge to flood protection practice. Potential spill-over: the developed knowledge network can strengthen valorization of scientific insights beyond the coastal protection sector.

- Sustainable Delta Cities (Netherlands)[24]
  Pilot projects for integral urban development in delta's. The integral perspective can be beneficial for e.g. the deepsea and shortsea shipping sector, because harbour development is integrated with coastal protection. Consequently, conflicting interests can be efficiently addressed.
- Building with Nature (Netherlands)[25]
  Using natural processes when realizing infrastructural measures. An example is the Sand Motor, which is an efficient beach reinforcement method using natural processes to spread out sand over the coastline. Understanding of natural marine processes can benefit all sectors which (indirectly) depend on natural variability, e.g. sand production or offshore engineering.
- Flood Control (Office in Netherlands, international setting)[26]
  Development of monitoring and modelling to provide accurate flood maps for design as well as calamity management. For calamity management, focus is on swift flooding forecasting, clear presentation of these forecasts and decision support tools. For spill-overs, see Chain of Safety.
- Networking initiatives (Netherlands)
  Examples are The Water Governance Centre, the Network Delta Technology and the Working Group Innovation Acceleration. They all focus on connecting people and breaking down barriers for innovation in the entire water sector[27]. For spill-overs, see FCERM.
- HafenCity (Germany)[28]
  Flood resilient land use, where ground floors of buildings can be flooded in extreme events.

HafenCity

Hamburg is setting new standards in developing a new city area along the Elbe. On an area of 157 hectares, a lively city with a maritime air is taking shape, bringing together workplace and residential uses, culture and leisure, tourism and retail facilities. The intensive interaction between land and water can be regarded as unique, since HafenCity is not surrounded by dikes, nor cut off from the water. With the exception of the quays and promenades, the whole area will be raised to between 8 and 9m above sea level. The concept of building on artificial compacted mounds (warfts) retains access to the water and a typical port atmosphere, while guaranteeing protection from extreme floods.

- Temporary and flexible flood barriers development (Netherlands)[29]
  Flood barriers which allow multifunctional land use (flexible barriers) or emergency reinforcements (temporary barriers).
- 'IJkdijk' (Netherlands)[30]
  Innovative dike monitoring based on sensor systems. Can lead to significant inspection and maintenance savings as well as delayed investments.

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23 http://evidence.environment-agency.gov.uk/FCERM/en/Default/HomeAndLeisure/Floods/WhatWereDoing/IntoTheFuture/ScienceProgramme/ResearchAndDevelopment/FCRM.aspx

24 http://www.zuidvleugel.nl/content/duurzame-deltasteden

25 http://www.rijksoverheid.nl/documenten-en-publicaties/rapporten/2008/01/02/building-with-nature.html

26 http://www.floodcontrol2015.com/

27 http://www.snellerinnoveren.nl/pagina_rc.asp?id=3387
http://www.watergovernancecentre.nl/over-ons/

28 http://www.hafencity.com/

29 http://repository.tudelft.nl/view/hydro/uuid:0a4f51b0-d021-4311-b202-143269df43dd/

30 http://www.ijkdijk.nl/en/

2.3.2 *Threats*

The main threat for the sector regards competition from other world areas and local demand. Declining government budgets in combination with limited economic growth put pressure on the demand for flood risk measures in the North Sea basin. Additionally, in other world markets the sector faces fierce price competition. The challenge for the sector lies within maintaining and/or developing a favourable price/quality ratio for a competitive position. This will significantly lean on innovations, as described above.

3 Drivers and barriers for growth

The table below shows the results of the SWOT analysis discussed in chapter 1 and 2, indicating examples of how the strength, weakness, opportunity or threat can manifest. Table 3.2 shows the economic, social and environmental aspects of the observed trends.

Table 3.1 Strengths and weaknesses analysis of the most promising economic activity

	Drivers for Growth		Barriers for Growth	
	Strength + opportunity	Example	Weakness + threat	Example
Public finance for investments	Strong awareness of governments and multi-annual funding schemes in place	Long term budget commitments providing stable funds over time to organise multi-annual protection programmes	A. Due to economic crisis less budget available. B. Investments liable to political priorities	Postponement of investments
Innovation	Innovative sector	See list of innovations above for full overview. A selection: Building with nature, Coastal change pathfinder, Sustainable delta cities	Integrated solutions are needed in coastal areas.	Current knowledge is fragmented and cooperation within one cluster limited
Education and knowledge infrastructure	Well developed in North Sea basin	Well known research institutes: Deltares (NL), Hydraulic Research Wallingford (UK) and Danish Hydraulic Institute (DK); dedicated Master programmes at various universities; also wider marine sector education systems in place (relevant to all marine sectors).	Expected reduction in number of well qualified technical operational personnel	Shortage of technical personnel already observed in other sectors[31]
Long history of coastal protection activities	Publicity of the coastal protection sector expertise	Global export of expertise.		
Climate change	Increasing demand for flood risk management	See De Moel (2010)[32]		
Economic growth	Increasing demand for flood risk management			
Modern risk approach: probability * impact	Integrated multidisciplinary flood	Innovations reducing flood impacts:	Decreasing demand in traditional flood	Detrimental for sectors active in the

[31] http://www.ey.com/Publication/vwLUAssets/Business_risks_facing_mining_and_metals_2011-2012/$File/Metal_Mining_paper_02Aug11_lowres.pdf

[32] http://dare.ubvu.vu.nl/bitstream/handle/1871/38274/dissertation.pdf;jsessionid=CFC2F6964982AFD69E4F629B1E81F57B?sequence=1

	Drivers for Growth		Barriers for Growth	
	Strength + opportunity	Example	Weakness + threat	Example
	risk management	Chain of Safety, Flood Control 2015, Hafencity	risk measures	realisation of these measures
Occurrence flood events	Emergency events resulting in increased attention calling upon Northsea based skills & services	See Katrina and Sandy aftermath in the US and advisory role for Dutch coastal protection specialists.	Low prioritisation for flood risk management with infrequent flood occurrence	Long periods of time with decreased turnover for the sector
Monitoring	Reducing uncertainty in flood risk assessment	Innovations: Digital Delta, Flood Control 2015		
Legislation	Prioritizing flood risk management	FCERM flood protection programme		
Other production input factors			Increasing costs for flood risk measures	Oil price, personnel, expertise

Table 3.2 Key impacts of the observed trends on the sector

Type of impact	Key impacts	Extent of impact
	Economic	
Competitiveness, trade and investment flows	The global competitive position of Europe is affected by all drivers which influence the approach and costs of coastal protection. Changes in the coastal protection approach are for example the 'risk * impact approach' or the change from a technical towards a more integral cross-sectoral approach. The global competitive position also benefits from the North Sea countries' long history of flood protection. Drivers affecting the demand for coastal protection (budget availability and risk awareness) in Europe influence experience, innovations and expertise in coastal protection. As such, they indirectly affect Europe's competitive position.	Medium
Operating costs and conduct of business/Small and Medium Enterprises	Traditional coastal protection works is capital intensive. As such, investments in the sector are focussed on capital and the players are primarily large dredging firms. The transition towards more integrated coastal area development, however, provides an opportunity for small en medium enterprises to play a bigger role.	Medium

Type of impact	Key impacts	Extent of impact
Administrative burdens	The environmental impact of coastal protection works plays an increasingly important role. Consequently, the sector is confronted with administrative burdens with respect to environmental impacts. With respect to small and medium enterprises, this is an additional limitation, because of the required expertise. On the other hand, they can play a more important role by supplying expertise specifically for these issues.	Large
Innovation and research	The coastal protection sector is a continuously innovating sector. Many different innovations, see chapter two, are currently under development or have already been developed.	Medium
Social		
Employment and labour markets	The 'education and knowledge infrastructure' driver will likely cause shortage of qualified technical personnel. These impacts will be mitigated by the transition towards a more integrated coastal protection sector. The required labour will move from mostly dredging and engineering towards broader disciplines. A significant amount of the required labour will still need to have a technical education.	Medium
Social inclusion	The trend is that coastal protection will become a more complex sector. Consequently, more labour with a higher education and with a differing education will be required.	Limited
Access to educational systems	n.a.	-
Environmental		
Impact on climate	The sector's impact on climate change is mostly driven by fuel use during dredging and other engineering works. The drivers affecting the production volume will therefore affect the impact on climate change. One of these drivers is the innovations driver, which could reduce the required dredging effort. For example by more efficient dredging (building with nature), tailoring protection levels (monitoring) and reducing flood impact instead of probability (new risk approach).	Limited
Transport and usage of energy	Similar to the drivers with impact on climate as described above.	
Impacts on biodiversity	The coastal protection sector potentially has a significant impact on biodiversity, water quality, resources and the environment as a whole. This is mainly due to the strong interference in the natural system. The trend is that these impacts are increasingly being taken into account. Therefore, the impact can be beneficial as well as detrimental. The classic coastal protection activities do, however, reduce diversity (by shortening the coastline or placement of barriers) and put pressure on (by emitting fuel and moving sediments / nutrients) the natural system.	Medium
Impacts on water quality and resources		Medium (temporary)
Likelihood and scale of environmental risks		Limited

4 Growth scenarios for the sector

4.1 Description of the nature of the economic activity and value chain

North Sea countries, notably the Netherlands, Belgium and the UK have coastlines susceptible to erosion. The low-lying Netherlands as well as the western part of Belgium are most vulnerable also due to high concentration of population and assets in low altitude regions. The backbone of the coastal protection sector is therefore also found there: four marine contractors (e.g. Boskalis, DEME, Jan de Nul and Van Oord) who jointly account for some 80% of the global dredging market, as well as shipbuilders (e.g. IHC) and equipment manufacturers (e.g. VostaLMG), research companies (e.g. Deltares, Hydraulic Research Wallingford and Danish Hydraulic Institute) and engineering companies. The GVA and employment generated by this sector is fairly small compared to some other marine sectors. However, the economic relevance of this function is still substantial since it enables other maritime economic activities or results in a higher economic value of the economic activities in the coastal area. Furthermore there are substantial spill-over effects from coastal protection to other marine sectors, e.g. by providing technologies to develop infrastructures or other services. Coastal defence can be seen as the catalyst for all kind of marine activities such as coastal development, land reclamation, port development, offshore techniques (offshore energy, deep sea mining).

4.2 Potential development

Coastal protection is a worldwide growing issue. Several countries in the North Sea and English Channel basin are relatively well advanced. They have a long history of coastal protection activities, providing high skills level and top players in executing works, both within Europe and as an export product. The region can promote this as a selling point and increases its' global competitive position which could result in growth. Massive efforts in research and technological development are made to improve sustainable and safe coastal regions, which also contribute to coastal protection works and services as an EU export product. Examples of coastal protections outside Europe are the support after Katrina and Sandy in the US and involvement in coastal master planning in delta countries like Bangladesh, Indonesia and Vietnam.

A second growth potential already materialised is the use of technologies for a multitude of other marine sectors (ports construction, access channel dredging, support to constructing offshore wind platforms, etc.). Furthermore coastal works appear to be more and more designed for multi-use (e.g. port breakwaters also contributing to coastal protection, suppletion benefiting coastal tourism, coastal barriers acting as energy plants, protection technologies serving marine species development).

However, a threat for the global competitive position of European marine contractors is an increasing competition from companies outside Europe who offer lower prices. Since public tenders more and more focus on price instead of quality, European contractors (who focus on value for money) have difficulties to match the financial offers from competitors especially for contracts elsewhere in the world.

The North Sea based coastal protection sector is expected to grow in terms of jobs and turnover worldwide based on its strong current position and on innovations taking place in terms of environmentally sound techniques, the design and testing of multi-functional coastal infrastructure

and generally the strong position of the research and engineering institutes from the region. The increasing completion from contractors in Asia is expected to curb the growth of the sector to some extent.

4.3 Uncertainties: external drivers and requirements

The core driver of growth of the coastal protection sector has always been the actual flood risk/erosion risk in coastal areas. Whether or not this will lead to growth in the sector depends on the amount of urgency given to the issue of coastal protection (perceived risk). The actual risk and perceived risk are driven by numerous factors.
The actual risk depends on climate change, economic growth, (the flood resilience / erosion vulnerability of) land use and contingency planning. The perceived risk depends on historic flood/erosion events, government budgets, monitoring efforts and flood protection legislation. Further drivers for the sector are international competition, oil prices, numerous innovations and scarcity of (qualified) personnel, land and other resources. Another driver is the pressure to develop eco-friendly approaches to coastal protection, resulting in an increased application of soft structures as opposed to the historic use of hard structures.

The sector is expectedly able to adequately respond to increases in demand. Currently, innovations are being developed within the coastal protection sector in order to adequately cope with the mentioned drivers.

4.4 Synergies and tensions

Developments in the coastal protection sector can spill-over to other marine sectors. Because coastal protection is a driver behind scientific research for coastal processes, these spill-overs are numerous. They can be categorized as follows:

1. Increased insight in (marine) natural processes, for example meteorological, tidal and sediment patterns. This insight is beneficial for numerous offshore activities like wind energy, oil and gas and sand mining. Furthermore, onshore climate adaptation with respect to water management also benefits from these insights;
2. Related to these insights, the availability of (marine) data and processing methods. An example is mapping of oceanic sediment, which can be useful for offshore construction as well as sand production;
3. Urban / regional development. Coastal protection as an integral challenge can strengthen urban / regional development.

Tensions resulting from coastal protection primarily result from resource requirements:

1. Land use required for flood protection provides limited possibilities for other functions;
2. Physical resource requirements, competing with (offshore) construction;
3. Labour requirements, competing with all sectors requiring technical personnel.

4.5 Framework conditions

EU policy

Although coastal protection is important on a European wide scale and in many cases has a transboundary character there is no European

legal requirement concerning coastal protection. Three different EU policies indirectly affecting the sector can be distinguished. (1) Policy asking member states to reduce coastal flooding risk by taking adequate measures (Flood Directive), (2) framework for maritime spatial planning and integrated coastal management and (3) directives aiming at a better coastal environment like Natura 2000, Marine Strategy Framework Directive and Water Framework Directive.

National policies regulating coastal protection

Coastal protection policies differ between the North Sea basin countries. In the Netherlands, safety standards for all flood defences have been established by law and coastal erosion management has been translated into an on-going coastal nourishment policy. The opposite exists in Belgium, Denmark and Norway. To date, Belgium has no law or directive regulating the protection of the coast against flooding by the sea and is applying one safety level for the whole coast. The general tendency in the coastal protection policy of Denmark can be summarised as “wait and see”. The Danish tradition of rather strict spatial planning regulations limits the impact of flooding along the coastline and in case of flooding in uninhabited areas, land is given back to the sea. The Norwegian coast is a fjordic coast, and much less sensitive to erosion than the coasts of most other North Sea countries. Especially the UK North Sea coast is facing severe erosion. In France, UK and Germany, coastal protection policies are decentralised.

Additional conditions needed?

Although limited EU policy is available and can be considered as conditions for coastal protection management and implementation of measures, there is no need for additional EU policy. The sector is able to work within the existing framework conditions.

Attention could however be paid to cooperation within the sector since it is an important condition for growth. Cross border cooperation on knowledge sharing between national and regional authorities already takes place. Cooperation within the value chain in an early stage is expected to result in more cost-effective solutions, which is needed to remain competitive on the long term and consequently leading to growth and jobs.

5 Joint actions leading to growth and jobs

Cross border cooperation: national and regional authorities

Cross border cooperation between national and regional authorities mainly exist on a knowledge development and knowledge sharing basis. Examples of cross border projects with coastal defence authorities from Belgium, UK, The Netherlands, Germany, Norway, UK, Sweden and Denmark[33] are:
COMCOAST, S@S, COMRISK, ESCAPE, FRaME, FLOWS, HARBASINS, SAFECOAST, STORMRISK, Chain of safety, SUSCOD. For more information on these projects, please refer to http://www.northsearegion.eu/iiib/projectpresentation/details/&tid=25&theme=2

ComCoast project

The ComCoast project worked on the future approach on safety against flooding around the North Sea. The project aimed to achieve a more gradual transition zone from sea to land, creating benefits for the wider coastal community and environment. In this approach safety and spatial use in the coastal defence zone were combined. Bringing in practice and experiences from other countries contributed to a high rate of attention. Experiencing the different approaches of each country was considered useful.

Cross border cooperation between national and regional authorities results in better cooperation between the North Sea countries and sharing of knowledge, but is doesn't have a significant impact on growth and jobs.

Cross border cooperation: coastal protection industry

As discussed in chapter 1, the coastal protection sector consist of engineering firms, dredging and marine contractor firms, supplier industry and research institutes. Cross border cooperation will take place every now and then. The large marine contractor firms have in general the capacity to implement a contract on its own and can be considered as competitors instead of partners. Nevertheless, there are cases showing that the large contractors from different countries work together especially in markets outside Europe, see below.

Examples of cross border cooperation by contractor firms and suppliers

Dredging company Dredging International (part of DEME-groep from Belgium) in cooperation with the Dutch company Van Oord won a contract of EUR 90 million euro for dredging the harbour of Gladstone in Australia.

Compañia Sudamericana de Dragados, a daughter company from dredging company Jan De Nul (Belgium) in cooperation with Royal Boskalis (The Netherlands) are constructing and maintaining the Argentina Port of Bahia Blanca.

IHC Merwede, a Dutch supplier of ships and equipment for dredging, offshore and mining activities, and DEME, a Belgian dredging, environmental and marine construction group, will enter into a joint venture for deep-sea mining activities. Under their cooperative agreement, IHC Merwede will be responsible for the development and construction of technical solutions, while DEME will be responsible for operations. Together the companies will offer a unique pioneering total solution. The joint venture will be known as OceanflORE (http://www.deme.be/Press/index.asp?DisplayStartNumber=101).

[33] Not all countries participated in each project

Within the North Sea, on a case by case basis such cooperation models can also be found, as well as between contractors and engineers, suppliers, and researchers.

According to former director of Van Oord, intensive cooperation between designers, engineers, contractors should start in the design phase of a coastal protection project. Bringing together in an early stage designers and contractors will result in more cost-effective solutions, which is needed to remain competitive on the long term.

Conclusion

Cooperation within the sector on a national level or cross border cooperation is considered a condition for growth of the sector. Cross border cooperation takes place on knowledge sharing basis between national and regional authorities. Cooperation within the value chain can bring the sector competitive advantages and consequently leading to growth and jobs. This kind of cooperation should be increased in the future.

6 Conclusions

For this sector it is not necessary to introduce policy or sources of funding to stimulate growth and jobs. During the past years, the sector demonstrated to develop well without specific policies in place. Policy should focus, like it does now, on setting the conditions for coastal protection which then have to be taken into account by the sector. These conditions are for example sustainable growth of maritime and coastal activities, sustainable use of coastal and marine resources, environmental regulations etc.

Since coastal protection contracts in the future are expected to have a more integrated character (for instance coastal protection in combination with port development, tourism development etc.), cooperation between different actors in the supply chain is needed. Cooperation between these partners should be encouraged and will realise in cost-effective and innovative solutions. This cooperation can be stimulated in two ways: first of all, paying attention to cooperation in the tenders for coastal protection works and secondly, like is currently done in The Netherlands, stimulating cooperation by preparing a strategy for the delta technology sector together with all players of the value chain.

The sector will benefits from clear political priorities regarding coastal development and the time schedule in which coastal protection measures have to be implemented in order to estimate the required resources (equipment and staff). Furthermore, the sector needs to get access to long term credits for large investments. Currently, due to the financial crisis, it is difficult to get these credits. Furthermore, attention should be paid to education of technical personnel, since a shortage of well educated staff is expected in the near future. National governments could stimulate young professionals to choose a technical education.

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