JUNE 2013
DG FISHERIES AND MARITIME AFFAIRS

Study to support Impact Assessment of Marine Knowledge 2020

FINAL REPORT

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APPENDICES

Executive summary

The improvement of marine knowledge is one of the main objectives of the European integrated maritime policy. In 2010, the European Commission in its Communication on Marine Knowledge 2020 presented a strategy on improving marine knowledge as a "key element to achieve smart growth in the European Union in line with the 'Europe 2020' strategy". The objectives of the Marine Knowledge 2020 strategy are to reduce operational costs related to data use, increase competition and innovation from marine knowledge and to reduce uncertainty on the state of the oceans and seas.

The present study is aimed at gaining a deeper understanding of the current practices as well as opportunities and benefits of future marine knowledge sharing. The study includes seven components covering a set of 18 individual questions to be answered. The components are:

1 Marine data in the licensing process
2 Costs of data for Marine Strategy Framework Directive
3 Cost of data for offshore wind farms
4 Legal basis of Regulation or Directive
5 Innovation from marine data
6 Reductions in uncertainty
7 Options for governance of EMODNet

The study is being undertaken by COWI A/S in cooperation with Ernst & Young. COWI was the lead responsible for components 1 to 4 and 7, while Ernst & Young took lead on components 5 and 6.

Overview

The terms of reference defined 18 the specific evaluation questions which were answered based on data collection exercise involving surveys, questionnaires and interviews combined with literature review.

Error! Reference source not found. provides a summary answers to each of the tudy questions.

Table 0-1 Summary of findings by each study question

	Study question	**Findings**
(1)	Do potential operators of licensed activities mentioned in point 2.2 pay for meteorological, bathymetric or geological data when preparing their application for a licence?	It seems that in about half the Member States data have to be purchased. Their costs are however relatively minor compared to overall licence costs. The costs of data in relation to Environmental Impact Assessments (EIAs) are often not known by the licence or permit applicant as the EIAs are done by external consultants and the purchasing of data is not billed separately.
(2)	Would they request more data (i.e. higher resolution in time or space) if it were substantially cheaper or easier to access?	The replies indicate that the licensees only collect the data necessary for the preparing the application so there is no indication that further data would be requested if data were either cheaper or easier to access.
(3), (4) (5)	Is the licensee obliged to hand over to public authorities the data collected or acquired in order to plan, develop or engage in the licensed activities including marine and coastal aquaculture, renewable energy, minerals extraction, oil exploration and exploitation, port harbour and marina development and pipeline and cable laying	No general answer can be given on this question. The obligation to hand over to public authorities, marine data collected or acquired in relation to licensed activities varies greatly across sectors and Member States. Of the ten countries for which information was received, in 7 there is an obligation to hand over marine data in at least some of the marine sectors. In most cases this obligation covers all phases of marine projects, i.e. siting, planning, construction and operation.
(6)	How much effort will Member States spend up to 2020 on data acquisition, management and dissemination (including enabling access to the Commission and the European Environment Agency) in meeting the requirements of the Marine Strategy Framework Directive?	For the initial MSFD assessment in the 22 coastal Member States and Croatia a total costs of EUR 45-55 million was estimated. The estimated effort up to 2020 can be estimated to be in the range of EUR 66-73 million, consisting of the costs of existing and new monitoring programmes (see questions (7) and (8))
(7)	How much of this cost is assembling existing data (i.e. data already collected, or being collected for other purposes)?	The estimate of yearly cost of assembling data from existing monitoring programmes based on an upscale of data from 9 Member States is EUR 45-52 million This could be an underestimate as it most likely do not include all relevant monitoring programmes.
(8)	How much will be spent on collecting new data (i.e. data from new monitoring and survey programmes that would not have been collected without the Marine Strategy Framework Directive needs)?	Estimate of yearly costs for new monitoring programmes: order of magnitude estimate EUR 20 million The estimate of the costs of new monitoring programmes is likely to be an underestimate as only very few Member States were able to provide an estimate. In many cases the decisions on new monitoring programmes have not yet been made and hence, it is difficult for the Member States to provide estimates.
(9)	What marine data will be required for planning, building and operating offshore wind farms in Europe up to 2020?	Based on consultation with the off shore wind sector supplemented by literature reviews and expert assessments, the different types of data are described in chapter 4.
(10)	How much will be spent collecting, purchasing, assembling and processing these data?	Using the same approach as for Question 9, the costs of data have been estimated. For an "average" offshore wind farm of 200 MW, the total data costs for planning, construction and operation could amount to EUR 19 million. With projections of new capacity in the order of 35-38 GW in the period up to 2020, total data costs for the sector could amount to EUR 3.4 - 3.7 billion. The major part of the costs, are costs for geotechnical site surveys
(11)	What legal basis could be used for a Directive or Regulation on marine knowledge that meets several objectives? Are there any examples?	Both the issues of legal basis and legal instruments have been assessed, and key aspects are presented.

	Study question	Findings
(12)	Assuming that historic and real-time data were available on parameters such as chemical pollution, non-native species, coastal erosion, storm intensity etc. what services based on these and other data: › Might reduce risks for aquaculture producers?	In total 15 case examples have been identified and assessed concerning description of problem/opportunity, the effect of additional data and the link to Knowledge 2020 and finally a description of the innovative service and an estimate of the potential economic benefits. The 15 case studies covering the four sectors demonstrate that additional marine data can promote innovation and suggest that there are significant economic benefits.
(13)	› Might enable insurance companies in coastal regions to provide a better assessment of risk?	
(14)	› Could support a longer season for coastal tourism?	
(15)	› Could help the bio-economy discover new products (pharmaceuticals, enzymes, cosmetics etc.)	
(16)	The contractor should provide three more examples of the economic benefits of reduced uncertainty in the behaviour of the sea or the state of the seabed and marine life.	In total 3 examples of reduced uncertainty have been identified and assessed. They demonstrate that there could be significant economic benefits from reduction in uncertainty of the state of the oceans and seas.
(17)	How would such an arrangement work? Are there any examples (other than EU Agencies)?	The arrangement of the work was described and different organisation options assessed including descriptions of examples of management structures.
(18)	Could it be done through the Joint Programming Initiative on Healthy Seas and Oceans? Or through the Joint Research Centre? Or through an executive agency? Or through a public-private partnership? What would be the costs and benefits in each case?	The organisational options have been assessed and the advantages and disadvantages of alternative options are presented and described.

A further summary of each study area is presented in the following sub-sections of the executive summary.

Marine data in the licencing process

The study has investigated whether licence or permit applicants pay for certain types of marine data when preparing the applications. The assessment has indicated a varied situation regarding payment for bathymetric, meteorological and hydrological data. License or permit applicants have to pay for some data but often they have to do their own data collection which is more costly.

Table 0-2 Potential payment for bathymetric, metrological and hydrological by permit or licence applicants in selected Member States

Bulgaria	Licence applicants have to pay for marine data
Denmark	Licence applicants have to pay for marine data
Cyprus	Marine data free of charge (information from the ports sector)
France	Licence applicants have to pay for marine data (information from the ports sector in La Rochelle)

Germany	Licence applicants have to pay for marine data products, but not for data sets (information only available for renewable energy and cable and pipeline laying)
Norway	Licence applicants have to pay for marine data
Romania	Marine data free of charge (unless the marine data come from research institutions/agencies)
UK	Some marine data free of charge

Source: Results of industry association's survey

A second issue in relation to permits or licences is whether there are obligations for the applicants to hand over the collected data to the relevant authority. A majority of Member States responding to a survey (ten out twelve) replied that they have obligations for licence or permit applicants to hand over data. The requirement usually does not concern commercially sensitive data. Furthermore, few Member States collect data in the INSPIRE format. Data is often made available for re-use upon request.

Table 0-3 Obligations to hand over data to public authorities by permit or licence applications

Bulgaria	Obligation to hand over data varies between sectors and phases of operations (siting, construction, operation)
Croatia	Obligation to hand over data
Cyprus	Obligation to hand over data in the aquaculture sector
Estonia	Extensive obligation to hand over data
England	No obligation to hand over data
Germany	Information only available for renewable energy and cable and pipeline laying: Obligation to hand over certain marine data
Iceland	Obligation to hand over data for all sectors
Ireland	Obligation to hand over data in aquaculture, renewable energy, minerals extraction, port, harbour and marina development and cable and pipeline laying
Latvia	Obligation to hand over data from monitoring activities for all sectors (Aquaculture n/a)
Northern Ireland	Information only available for renewable energy, mineral extraction, port, harbour and marina development and cable and pipeline laying: Obligation to hand over marine data
Norway	Obligation to hand over data (no information available for oil exploration and exploitation)
Romania	Obligation to hand over data (n/a for renewable energy and minerals extraction as there are no such offshore activities in Romania)
Scotland	No obligation to hand over data
Spain	No general obligation to hand over data

Source: Results of Member State survey

Cost of data for the Marine Strategy Framework Directive

The Marine Strategy Framework Directive (MSFD) includes a number of requirements where there is need for collection of marine data. This study has investigated the costs of data collection activities based on a questionnaire survey among the Member States.

Ten Member States have provided information and they represent a good sample of all EU coastal states (location, population, GDP level, coastline, geography).

The reported costs have therefore been adjusted using GDP levels and labour costs and scaled up for 22 coastal states using average costs. Due to the diverse geography, economic and social properties of the respondent countries this method provided the best results. The estimates that have been calculated in response to the questions in the Terms of Reference for this project are the following:

› Estimates of the efforts related to the initial assessment required by the MSFD in the 22 coastal Member States and Croatia: EUR 45-55 million.

› Estimate of yearly cost of assembling data from existing monitoring programmes: EUR 45-52 million.

› Estimate of yearly costs for new monitoring programmes: around EUR 20 million as an order of magnitude estimate.

› The estimate of the effort related to the initial assessment is the least uncertain of the estimates. Regarding existing monitoring programmes that provide data to the MSFD, Member States might have included mainly the environmental programmes. Data are typically also provided from other monitoring activities for example monitoring of fisheries. Hence, the costs of existing programmes that provides data for the MSFD are likely to be underestimated.

The estimate of the costs of new monitoring programmes is also likely to be an underestimate as only very few Member States were able to provide input on new programmes. In many cases the decisions on new monitoring programmes have not yet been made and hence, it has proven difficult for Member States to provide estimates that could support the assessment.

Cost of off shore wind farms

The study has included a comprehensive assessment of all types of data costs in relation to planning, construction and operation of off-shore wind farms

The assessment has been developed as the costs of one off-shore wind farm with a capacity of 200 MW and then up-scaled that estimate over the 35 to 38 GW of off shore wind capacity which is expected in EU by 2020.

The estimation indicates that data costs of an offshore wind farm of 200 MW are in the order of EUR 19 million and with projected new capacity to be installed in the order of 35-38 GW, the total data costs in the sector could be in the order of EUR

3.4 - 3.7 billion. The major part of the total costs, are costs for geotechnical site surveys.

The costs of the geotechnical site surveys depend very much on the conditions at the specific location and they could vary with plus/minus EUR 5 million compared to the average estimates presented here. It means that the costs for one 200 MW offshore wind farm would be in the range of EUR 14 million to EU 24 million.

Table 0-4 Estimated costs of establishing 36-39 GW wind farm capacity in Europe by 2020

	Mean cost 200 MW Wind farm €	Costs till 2020 for establishing 35-38 GW Million €
Planning Phase		
Metocean data	740,000	130-141
Bathymetrical/geophysical/geo-technical data	1,800,000	315-342
Benthic flora and fauna data	310,000	54-59
Fish data	125,000	22-24
Birds data	550,000	96-105
Marine mammals data	370,000	65-70
Total planning phase	**3,895,000**	**682-741**
Construction phase		
Metocean data	43,000	7.5-8
Bathymetrical/geophysical/geo-technical data	12,900,000	2,258-2,451
Benthic flora and fauna data	175,000	31-33
Fish data	70,000	12-13
Birds data	300,000	53-57
Marine mammals data	200,000	35-38
Total construction phase	**13,688,000**	**2,397-2,600**
Operation phase		
Metocean data	66,000	12-13
Bathymetrical/geophysical data	145,000	25-28
Benthic flora and fauna data	390,000	68-74
Fish data	115,000	20-22
Birds data	700,000	123-133
Marine mammals data	285,000	50-54
Total operation phase	**1,700,000**	**298-324**
Grand total costs	**19,283,000**	**3,377-3,665**

Legal assessment

The legal assessment has included considerations of the possible legal basis for the alternative options for the Marine Knowledge 2020 initiative.

Option	Impacts (positive/negative)	Legal basis
1. A 'do nothing approach' meaning no changes to existing legislation	Increasing uneven implementation at MS level regulatory uncertainty and no reduction of costs/ continued distortion of competitive conditions/Internal Market and thus not sufficient stimulation of innovation	As before
2. Amending existing legal instrument(s)	Depends on clearer framing of options on legal measures. The assumption is that a legal initiative will lead to greater legal certainty, reduction of costs due to the economic importance of open data including reduction of competitive market hindrances as well as increased stimulation of innovation.	Changes to the existing legislative acts will have to be made within the same legal basis of the Treaty.
3. New legislation	Depends on clearer framing of options on legislative or non-legislative acts. The assumption is that it will bring about enhanced legal certainty, lowering barriers for re-use of data and thereby reducing costs.	Legal basis for horizontal measures needs to be identified and agreed, either within existing legal Treaty basis for EU maritime policy or within the legal basis for horizontal environmental measures, depending on the framing of the exact option. In the case the options will identify legislative acts according to Art 288 TFEU (Regulations, Directives or Decisions) the ordinary legislative procedure in Art 294 TFEU shall be applied. Non-legislative acts will either have to be based on the Treaties or based on secondary legislation/implementing acts based on implementing powers procedure - 'comitology'- (Art 291 TFEU) or through adoption of delegated acts through delegated power to the Commission (Art. 290 TFEU)
4. Soft law measures	May to some extent facilitate application of the rules of the PSI Directive on licensing and charging. Will however not necessarily improve the uneven implementation at MS level to the same degree as with a legal action, so regulatory uncertainty and distortion of competitive conditions may still occur at the same scale.	Legal basis can be found within existing legal basis for EU maritime policy, as before.
5. One to more combinations of the above options ("package solution").	Depends on clearer framing of options on specific package. The assumption is that combining legal amendments with soft law measures will bring together the benefits from options 3 and 4 above and thus provide enhanced legal certainty, removal of barriers for promoting re-use of data, reducing costs and stimulating innovation.	Legal basis for horizontal measures needs to be identified and agreed, either within existing legal basis for EU maritime policy or within the legal basis for horizontal environmental measures, depending on the framing of the exact option.

Innovation from marine data and benefits resulting from the reduction of uncertainty

Improved marine knowledge, whether it be through better sharing of datasets on past and present events, improved coordination of research efforts, or other types of specific phenomena, can bring potentially significant economic, social and environmental benefits.

These benefits can be realised through the creation of innovative services and encourage the growth of emerging sectors, through the mitigation of risks and negative impacts, or through a reduction in uncertainty regarding the state of the oceans and seas. The benefits are therefore expressed in a number of different manners, which include:

- Avoidance of revenue/production losses
- Increase in profitability
- Reduction in costs
- Regional economic impacts.

Firstly, a number of case examples of innovations based on marine data has been identified and developed.

Subsequently also a number of case examples of the benefit of reduced uncertainty based on improved marine data has been identified and developed.

The following methodological issues and limitation should be kept in mind regarding the presented case examples of innovation and reduced uncertainty based on marine data.

- Largely based on existing documentation and studies
- Extrapolations of specific quantitative examples based on assumptions
- Specific examples that may not reflect the entire opportunities for the sector
- Specialists, whilst providing a sanity check of desktop research, do not necessarily represent the views of the entire sector
- Challenge in isolating the particular impact of "improved marine knowledge" in the development of an innovation or sector

The two tables below summarises the findings of the identified case studies, in terms of the importance of marine knowledge/data and a demonstration or estimation of the economic benefits.[1]

[1] For currency conversion, the follow assumptions have been made: $US1 = €0.78 and £1 = €1.17.

Table 0-5 Case study examples of innovation

Title	Hypothesis	Data needs	Economic benefits
Reduced risk to aquaculture production			
Early warning device for jellyfish blooms	Limited knowledge regarding the reasons for blooms, their impacts and potential mitigation strategies. An early warning system to anticipate blooms and better understand behaviour and impacts, and minimise damage to aquaculture production.	Widespread monitoring to obtain site-specific data on jellyfish populations, including their seasonal occurrence and abundance. Need to coordinate research at a regional level, and share results of studies.	Assuming that half of the 12% mortality rate due to gill disorders[2] can be attributed to jellyfish, and that the affected species are mostly Mediterranean mussels, as well as northern rainbow trout and salmon production (€1.4 billion market in 2009)[3], **addressing jellyfish impacts could assist in avoiding losses to production of € 84 million** (1.4 billion x 6%).
Offshore aquaculture: new sea-cage design	Expansion of offshore aquaculture requires cages designed to withstand extreme conditions, protect against invasive species, and production losses (escapes) and keep maintenance costs low.	Hydrographical data to optimise cage location, data on the structure and quality of the seabed, meteorological data to predict waves, currents, and information on past extreme weather events and real time monitoring.	New cage design could lower production costs through fewer visits, and minimising risk of fish escape. A study of the "Economic Feasibility and Impact of Offshore Aquaculture" in the Gulf of Mexico[4] provides an idea of the potential of the offshore aquaculture sector through improved cage design. This study concluded that a single farm operation directly employing only seven individuals for offshore production can provide an **additional annual regional economic output (direct, indirect, and induced effects) of at least $US 9 million (€7 million) and provide additional employment for at least 262 persons**, related to processing, feed production, distribution, etc.
Understand and address ocean acidification	Ocean acidity has an impact on the ecosystem, but it is not well understood. Understanding ocean acidification, and the impact it has on shellfish will assist in predicting and minimising further negative impact on the ecosystem (global observation network).	Data on behaviour of flora and fauna to changes in acidity, comparable paleo-data (past events and impacts), time-series data, real time monitoring data. Stronger links between research and industry.	Economic costs of reduced mollusc production due to ocean acidification in the EU 15 (at the time of study) will be **at least $US 500 million (€ 375 million) in 2100 under a business-as-usual scenario**.[5] This estimation of economic impact is only based on mollusc production. But because molluscs are the basis of many other fish feeding chains, the global impact of acidification in aquaculture (capture) should be even greater.

[2] Baxter, E., Rodger, H., McAllen, R., Doyle, T. (2011), "Gill disorders in marine-farmed salmon: investigating the role of hydrozoan jellyfish", Aquacult Environ Interact, Vol. 1: 245–257, 2011

[3] Facts and Figures on the Common Fisheries Policy, 2012 edition, DG MARE

[4] Posadas, B. C., and C. J. Bridger. 2005. Economic Feasibility and Impact of Offshore Aquaculture in the Gulf of Mexico. MASGP 04---. In Bridger, C. J. (ed.). Efforts to Develop a Responsible Offshore Aquaculture Industry in the Gulf of Mexico: A Compendium of Offshore Aquaculture Consortium Research. Mississippi-Alabama Sea Grant Consortium, Ocean Springs, MS

[5] Economic Costs of Ocean Acidification: A Look into the Impacts on Shellfish Production, Daiju Narita, Katrin Rehdanz, Richard SJ Tol, 2011

Better assessment of risk for insurance companies			
Insurance discounts through improved marine safety information	Through more reliable nautical charts and maritime safety information, insurance providers may be willing to offer products with reduced premium's resulting in lower insurance costs, which is a major operating cost factor for shipping companies.	Improved quality nautical charts – including topographic data, seabed features, and navigational hazards – as well as better coverage of open seas through hydrographical surveys. Meteorological data in order to anticipate natural events and protect both hull and cargo.	Marine insurance premiums are known for their volatility, with a complex array of internal and external drivers acting. However, improved navigational technology, owing, in large part, to greater availability of marine data, has significantly reduced risks associated with this industry. As an illustration of economic benefits associated with marine data, there is an agreement between a US marine system software company and insurance provider whereby **customers whose vessels are equipped with the MICAD Marine System** (a real-time marine data collection and management system which includes information, diagnostics, satellite communication, vessel and fuel management, and permanent archival of vessel data on each individual vessel or an entire fleet) **are offered a 20% discount on insurance products**.[6]
Managing natural disaster risk in Europe's coastal regions	Costs of weather-related natural disasters have been rising and in large part due to climate change. Data is highly fragmented and of little use for climatologists and actuaries seeking to better understand and plan for the effects of climate change.	Type of data needs can vary depending on the type of analysis and the disaster likely to occur – e.g. monitoring activities in flood prone needs rain-fall data, water level telemetry stream flow and storm surge, whilst climate change modelling needs reliable time-series data on a span of climatological indicators. There is a need for metocean data that is already widely collected by industry and public authorities, as well as coastal monitoring data on phenomena such as coastal erosion and flooding.	Economic benefits of improved risk assessment can be substantial in the long run. With losses in 2011 in Europe totalling over $US 9 billion (€7 billion), strategic investments in adapting Europe's coastal regions could result in **hundreds of millions in economic benefit**. For instance, if better modelling and monitoring allowed coastal adaptations to be only slightly more effective, **losses could be reduced by millions annually**. While this estimate is crude and does not take into account more unquantifiable benefits such as the long-term health of Europe's insurance industry, it gives an idea of how small investments may make a huge impact.
Improving the certification process for offshore wind projects	In a sector evolving at such a fast pace, underwriters can be hesitant about extending certain types of coverage to innovative designs. Independent certification provides outside assurance.	While more widely available metocean data cannot replace site specific data collection, as crucial environmental parameters can vary drastically over short distances in marine environments meaning developers need a 'high resolution picture' of the specific site, it could be highly valuable at other stages of the certification process, such the conceptual design phase and elaborating an effective maintenance strategy.	Insurance has an important role in supporting investment in offshore wind projects by providing security for investors. In the future, there is the risk of inadequate coverage for the level of investment needed. Certifying designs and subjecting prototypes to rigorous testing using marine data, particularly metocean data, will thus play an important role in **allowing underwriters to keep up with technological advances**. Furthermore, predicting remaining useful life under normal operating conditions will **allow operators to better manage their assets and adapt up-keep and maintenance strategies**. Quantitative estimatations of benefits for this example however were not feasible.

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Extend the coastal tourism season			
Coastal cleanup and awareness raising to attract and develop sustainable eco-tourism	Mitigate the negative impact of increased tourism flow, by raising public awareness. Minimise the impact on marine life and habitats through sustainable eco-tourism solutions.	Meteorological data, data on water quality, coastal erosion. Observation of movement of species, and their habitats. While, on the EU level, there is the Marine Strategy Framework Directive, a coherent framework for the systematic use of this data within the context of coastal development has been lacking.	Due to a lack of specific data on the eco-tourism industry, it is difficult to provide sound estimate for the growth potential of this market in Europe. However specific examples indicate benefits. A US study found the **economic benefits of improving beach water quality could increase the number of visitors by 1,538 visits per year for a total economic impact (local spending) of $US 45,000/year (€35,000/year) (at one beach).**[7] Water quality issues are estimated to impact the tourism industry in Blackpool, UK, **facing losses of £ 1 billion (€1.17 billion) over 15 years**. According to an EU survey in 2010, 500 EU beaches did not reach minimum quality standards. There is potential therefore that cleanup may **result in avoided losses of up to €585 billion over 15 years**.
Artificial reefs: surf and diving opportunities	Artificial reefs have the potential to increase sustainable coastal tourism through surf and diving revenues, but also protect marine species and therefore create potential dive and game fishing sites.	Bathymetry and topography, marine currents and meteorology, quality of water and salinity: to optimise location, material used and reduce impacts on environment	US studies have found that depending on its size and the method used, creating an artificial reef can cost from $US 46,000 to $US 2 million (€35,000 to €1.5 million).[8] In Florida, where there are some **2700 artificial reefs**, a study found that **non-residents and visitors annually spent $US 1.7 billion (€1.3 billion) on fishing and diving activities associated with artificial reefs**.[9] Similar potential may be possible for the EU.
Protection against coast erosion	Better coastal protection will save on structural damage and insurance costs, as well as enable sustainable management of tourism growth, minimising impact.	Data on past observations of meteorological events, current water flows, winds, water temperature, topography, bathymetry and human activity impacts to prepare an appropriate response to erosion.	Protecting against coastal erosion can provide very direct economic benefits, including lowering insurance premiums, saving productive coastal land and protecting tourist destinations that provide a crucial injection of revenue for many coastal economies. Beyond these direct benefits, there are also less tangible benefits. For example, a Portuguese study by Alves *et al*, using the Benefit Transfer approach, found that the **total value of coastal ecosystem services in central Portugal amounted to € 193 million annually and that expected ecosystem service value losses amount to € 45 million by 2058**.[10]

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[7] http://surfeconomics.blogspot.co.uk/2009/11/cost-of-poor-water-quality-at-surfrider.html
[8] Pendleton 'Understanding the Potential Economic Impacts of Sinking Ships for SCUBA Recreation'. 2005.
[9] 'Adams, Lindberg & Stevely 'The Economic Benefits Associated with Florida's Artificial Reefs'. 2006, 2011 (revised)
[10] Alves, Roebling, Pinto & Batista 'Valuing Ecosystem Service Losses from Coastal Erosion Using a Benefits Transfer Approach: A Case Study for the Central Portuguese Coast'. Journal of Coastal Research n 56, 2009.

Discovery of new bio-economy products			
Development of seaweed based products	Localising natural resources and a more stable cultivation process of algae will maximise the benefits for potential growth markets.	The potential economic return of cultivated algae is unknown, as there is a lack of long term trial data. Data on the location and availability of natural stocks based on prediction models and observations.	Given the two main potential markets that are bioenergy and biomaterials, the economic benefits of products based on seaweed are potentially very high. Nonetheless, it is difficult to estimate the economic benefit for potential uses at an early stage of development. As an example, **Irish seaweed production and processing sector will be worth € 30 million per annum by 2020** (the sector is currently worth € 18 million per annum).[11] In order to reach this target, there is a need to capitalise on the existing wild resources and augment supplies of high value seaweeds. Similar growth projects may be possible for other Member States if better data is available to develop the sector.
Innovation aquatic pharmacy products	Biotechnology companies looking for pharmaceuticals / enzymes to catalyse industrial processes need to know where to look. Data to locate these organisms has the potential to unlock the economic potential associated with new discoveries.	Bioprospecting, greater knowledge of sediments, habitats and sea-floor topography to better target scientific exploration. Extensive taxonomy of marine organism in order to create biobanks: type, focus and taxonomy of organisms, amount available, format.	The global market for marine-derived drugs was $US 4.8 billion in 2011 and is expected to be $US 5.3 billion in 2012. According to BCC Research, this **global market is forecasted to reach $US 8.6 billion (€6.7 billion) in 2016** at a compound annual growth rate of 12.5 % for the five-year period of 2011 to 2016.[12] Furthermore, 2011 research by BCC Research found mollusc to be the fastest growing market for marine-derived drugs, **expected to grow from $US 69.4 million in 2011 to $US 490.1 million (€382 million) by 2016** at a CAGR of 47.8%.[13]

[11] A Market Analysis towards the further development of Seaweed Aquaculture in Ireland, Máirtín Walsh, Lucy Watson, BIM
[12] "Global Markets for Marine – Derived Pharmaceuticals" cited in Market Research Reports and Technical Publications Product Catalog December 2012, http://www.bccresearch.com/report/marine-derived-pharma-markets-phm101a.html
[13] "Global Markets for Marine – Derived Pharmaceuticals" cited in Market Research Reports and Technical Publications Product Catalog December 2012, http://www.bccresearch.com/report/marine-derived-pharma-markets-phm101a.html

Protecting Biodiversity for Tomorrow's Blue Economy	Biodiversity is crucial for the health of ecosystems. Furthermore the genetic diversity of undiscovered marine resources offers an inestimable stream of future innovation for the blue biotechnology sector. In order to better manage ecological security and ensure a flow of future innovation, researchers and policy makers must first be able to better understand and measure biodiversity.	Biodiversity data comes from a wide spectrum of sources and goes beyond populations of specific species. It also requires data to feed indicators on phenomena such as pollution, non-native species, eutrophication, etc… Developing new tools and methods to measure the health of ecosystems and new modes of cooperation in order to improve the cost-effectiveness of gathering and analysing environmental data are key challenges for better policy making in Europe. Understanding and internalising the economic 'cost' of losing biodiversity will also act as a driver for better decision making.	While assigning economic value to ecosystem and biodiversity may seem reductive, the exercise can provide a sense of what Europeans stands to lose from future changes in biodiversity, although it glosses over ethical considerations such as the intrinsic or 'non-use' value of natural resources. Undiscovered species under threat of extinction, while they may have **little economic 'use value' can hold astronomical 'option value'** in that they may hold keys to future scientific advancement. For example, **significant value ($US 230–330 million[14] (€180 to 260 million)) has been attributed to genetic information gained from preventing land conversion** in Jalisco, Mexico, in an area containing a wild grass, teosinte (Euchlaena mexicana), that can be used to develop viral-resistant strains of perennial corn.
Other cases			
Sea-bed mining, mineral resources	By improving our understanding of the seafloor ecosystem, in terms of vulnerability, resilience and functioning of marine biodiversity, this can reduce the risks of seabed mining and potentially lead to development of commercial deep sea mining sector.	Further basic research on 'what lives where' and what affects the patchy nature of deep sea biotic distributions is needed to advance our understanding of this unexplored marine diversity and its associated biogeographic classifications. Data needs include seabed substrata, deep sea life, currents, etc to plan extraction, design instruments and understand behaviour of lifeforms.	Without better marine knowledge, the risks and costs of deep sea mining far outweigh the potential economic benefits. An example of the potential economic benefits of deep sea mining is the Solwara 1 deep-sea mining project in Papua New Guinea. This project was due to commence in 2014, and it is estimated that it would bring in more than **$US 140 million (€109 million) to Papua New Guinea's economy in its first two years of operation and claim that about 70 per cent of the project's staff would come from the country**.[15] However there are concerns it will result in the destruction of a still unexplored ecosystem. These concerns need to be better understood, in order to weight up the costs against the potential benefits.

[14] Fisher, A. C. & Hanemann, W. M. Option value and the extinction of species. Adv. Appl. Micro-Econ.4, 169–190 (1986)
[15] Sarmiento, P. "Should deep-sea mining go ahead in Papua New Guinea?", January 2013

Data to optimise offshore wind energy yield	Current knowledge gaps lead to underestimation of energy yield. Better predicting energy yield can assist in improving site selection and therefore potential productivity of industry.	Information required includes wind data, air intensity, turbulence intensity, topography, in order to provide accurate wind energy estimations.	A better assessment of energy yield will have a **positive impact on the investment case, resulting in more confidence in project financing, reduction in cost through optimisation of site selection, and increase in potential production**. However quantifying the benefits are very difficult to estimate, given a lack of quantitative studies in this area. This said, it has been recognised that **innovation opportunities over the next 10 years can bring down the deployment costs of offshore wind by up to ~25%, with further savings after 2020 likely to bring down costs even further (up to circa 60% by 2050)**.[16]
Optimisation of turbine foundation design	Foundation costs can represent up to 40% of wind capital expenditure on offshore wind. The sharing of data from experimental offshore installations can help researchers validate new types of more cost-effective foundations.	Measured data from experimental offshore installations (different structures and technologies) to validate existing models. Quality time series on sea-state parameters, currents, sea surface elevation, also soil characteristics.	Cost effective design optimisation of turbine foundation means that installations can be installed more economically. An example in the UK suggested that **minor design changes could lead to significant savings in construction schedule and costs**. The designers decided to make minor modifications to the monopile by welding a flange to which the wind tower could be bolted thereby getting rid of the transition piece and the expensive grouting used to connect it to the monopile altogether.[17] However for this given example, quantitative estimates of the benefits in terms of cost and time savings have not been established.

[16] Technology Innovation Needs Assessment (TINA), Offshore Wind Power Summary Report, Innovation Coordination Group, 2012
[17] http://cdn.intechopen.com/pdfs/14804/InTech-Selection_design_and_construction_of_offshore_wind_turbine_foundations.pdf

Table 0-6 Case study examples of benefits resulting from a reduction in uncertainty

Title	Hypothesis	Data needs	Economic benefits
Protection of cables for offshore wind	Optimisation of cable protection will reduce risk of damage in long term, reduce costs in installation phase, as well as costs for ongoing maintenance.	Uncertainties would be reduced through better sea-bed data: seabed mapping systems that accurately chart depth, topography, slope angles and seabed type.	Economic damage to cables can potentially be significant as the repair of broken cables is very expensive. Even small areas of mischaracterized seabed can cause significant downtime to repair a damaged cable. The mean time to repair is months for conventional submarine power cables and longer repairs can be expected as cables are laid at deeper and deeper depths. As an illustrative example, in April 2012 the NorNed 700 MW direct-current cable connecting the Netherlands and Norwegian electricity systems failed, **halting production for 10 weeks, and resulting in lost earnings of around € 145 million**. The benefits of protective systems are confirmed through the fact that while cables make up 8% of investment, 80% of insurance enquiries refer to these systems. In an attempt to extrapolate on this example, we need to determine the number of cable failures annually and ideally the average duration of interruption. A study found that there is 1 cable failure per 1,000km of cable per year.[18] To determine the cumulative length of cable for offshore wind structures Europe, we take the total number of turbines (1,662) and multiply this by the average distance to shore of 29km (29km of cable exposed to risk of cable failure), resulting in a total of 48,198km of cable at risk of failure. Taking our previous assumption, if 1 cable failure occurs per 1,000km of cable per annum, there would be **48 failures per year, which would result in lost earnings, based on a 10 week break in production, of € 6.9 billion.**
Site accessibility to optimise operations and maintenance for offshore wind	Better accessibility results in reduced downtime losses, avoidance of energy production losses, and potentially prevention of costly repairs.	Actual weather conditions, forecasts of wind and sea state to optimise O&M. Data on wind turbine failure rate, data from access systems, supply boats, and crane barges, as inputs into models.	**An uplift in the wave height at which maintenance is possible could improve turbine availability from 80% to 90%, translating to a potential saving of £ 245,000 (or € 285,000) per 5MW turbine per year.** If this were applied to 50% of the 1,662 turbines installed and grid connected, totalling 4,995 MW in 55 wind farms in ten European countries at the end of 2012,[19] this would result in **combined savings of € 236.8 million per annum**.

[18] http://ocw.tudelft.nl//fileadmin/ocw/courses/OffshoreWindFarmEnergy/res00047/Module_9_wind_farm_aspects.pdf

[19] EWEA, European Offshore Statistics 2012, http://www.ewea.org/fileadmin/files/library/publications/statistics/European_offshore_statistics_2012.pdf

Hydrographic data to assist optimising ship navigation routes	Improved hydrographic data coverage will positively benefit navigation safety and protection of the marine environment, among many other benefits.	Lack of up-to-date charting and hydrographic survey data. In Europe, the most significant gaps are in the Mediterranean and Black Seas High resolution access to seafloor morphology and texture, covering topography, bathymetry, geology	Improved charts enable **cost reductions through faster transit for ships, more direct routes, reduced insurance costs, and avoidance of maritime accidents**. As an illustration, the National Oceanographic and Atmospheric Administration (NOAA) reported that **one additional foot of draught may account for between $US 36,000 and $US 288,000 (between €28,000 and €225,000) of increased profit per transit** into Tampa, Florida, USA.[20] Furthermore, the **economic benefits and savings associated with preventing marine accidents through more adequate surveys are significant**. For the example of the Sea Diamond, the bill footed by the owner company **cost $US 6 million (€4.7 million)**, while a **floating barrier that has been placed in the area of the wreck is monitored daily by a pollution-control vessel staffed by specialised personnel**, again at the shipowning company's expense.

[20] National Oceanic and Atmospheric Administration (NOAA), (2000), Technical Report NOS COOPS 031, National Physical Oceanographic Real-Time Systems (PORTS) Management Report. Silver Spring, Md.

Options for governance of European marine observation and data networks

The section on governance aims to assess the organisational and administrative aspects of running a secretariat to govern the “European marine observation and data networks”.

It is mentioned in ToR that “An ideal secretariat would (1) deliver an annual work programme to achieve a set of objectives.(2) negotiate approval of the work programme with a "governing board" (3) implement the work programme in a way that is compatible with the EU's Financial Regulation.”

The focus of the governance assessment has been on the qualitative analysis of the identified secretariat options in an effort to uncover the advantages and disadvantages of each one according to a number of parameters. A limited quantitative assessment was undertaken due the limited size and available operational budget of the secretariat.

In summary the following findings and recommendations on EMODNet project management can be drawn:

› **Full internalisation.** An internalisation of the secretariat would most likely centre on DG MARE. While this option would have benefits through direct control, planning and synergies, it would in most likelihood impose additional administrative and operational burdens on DG MARE;

› **Allocation of the secretarial tasks to an Executive Agency**. The role of Executive Agencies is clearly defined to manage programmes on behalf of the Commission and has proven so. EACI could be the more relevant agency to manage the secretariat based on the project management cycle and the themes of programmes dealt with.

› **Allocation of the secretariat tasks to a Regulatory Agency.** A Regulatory Agency could manage the secretariat. The more relevant agencies would be EEA or EMSA based on thematic and operational characteristics. However the mandates and tasks of Regulatory Agencies go beyond what is needed to run the secretariat and may prove to be more cumbersome in administrative terms. The Executive Agency model is more aligned to the direct needs of the secretariat and the European Commission.

› **Other options (Joint Initiatives)**. Of the other options examined the Joint Initiatives appear the more appropriate model. Especially Copernicus was an example of a relevant organisation to manage not only the secretariat but the programme in terms of thematic expertise and content of tasks. There seems to be possibilities of achieving synergies between EMODNet and the maritime part of Copernicus as the programme beneficiary group may to a large part be identical.

› **Private entities.** It was found that the value added of EMODNet is in providing the data (gathering, monitoring and basic processing) without restrictions and at marginal costs (as a public good). This and operational limitation in the financial regulation limits the attractiveness of having a private entity running the secretariat. It is envisaged that private entities can utilise the data provided by EMODNet and benefit from further processing it.

Overall, based on the relative limited size of the secretariat it is recommended that it should be placed in close proximity to the parent DG, in this case DG MARE, either internally in the DG or in an Executive Agency. One alternative option would be to assess if there are synergies with the maritime part of Copernicus and if merging the programme into Copernicus could benefit the implementation of both programmes.

1 Introduction

This report constitutes the final report on the Study to support the forthcoming IA on Marine Knowledge 2020. The report is submitted in accordance with the reporting schedule stated in the Terms of Reference.

This introduction section describes firstly the background and the objectives of the study. Secondly, the data collection process is described.

1.1 Study background

The improvement of marine knowledge is one of the main objectives of the European integrated maritime policy. In 2010, the European Commission in its Communication on Marine Knowledge 2020 presented a strategy on improving marine knowledge as a "key element to achieve smart growth in the European Union in line with the 'Europe 2020' strategy". The objectives of the Marine Knowledge 2020 strategy are to reduce operational costs related to data use, increase competition and innovation from marine knowledge and to reduce uncertainty on the state of the oceans and seas.

A central aspect of the strategy on improving marine knowledge is the integration of the fragmented regional and national systems for collecting and assembling marine data. In this context, the European Commission in 2010 launched an Impact Assessment on the European Marine Observation and Data Network (EMODNet). The purpose of this Impact Assessment was to contribute to the setting up of a common European network for the sharing of marine knowledge. As a preparatory action, projects for the establishment of EMODNet pilot portals were created for the sharing of hydrographical, geological, physical, chemical and biological data.

1.2 Purpose and delineation of the study

Against the background described above, the present study aims at gaining a deeper understanding of the current practices as well as opportunities and benefits of future marine knowledge sharing. It will use the Impact Assessment on EMODNet and the other work that has been undertaken as a starting point and take these activities further. It will supplement the current knowledge level and focus on benefits from improved marine knowledge as well as the role of the private sector in gathering and providing marine data.

The study has analysed current practices in the Member States regarding the gathering of marine data by the private sector in the process of applying for licensed activities and a possible re-use of this data by public authorities. It has collected information on the data collection, management and dissemination cost up to 2020 borne by the Member States for complying with the Marine Strategy Framework Directive and on the cost of data for offshore wind farms in Europe until 2020. Regarding benefits from improved marine knowledge the study provides examples of innovation from marine data in the aquaculture, insurance, tourism and bio-economy sectors. Additional benefits could arise from reductions in uncertainty in the behaviour of the sea or the state of the seabed and marine life. The study therefore provides examples of economic benefits from such reduced uncertainty.

Additionally to benefits from improved marine knowledge and the role of the private sector in data gathering the study assesses the legal basis for a Regulation or Directive on marine knowledge. Finally, the study provides examples of governance options for the European Marine Observation and Data Network as well as costs and benefits of the proposed governance options.

In summary, the study includes seven components:

1 Marine data in the licensing process
2 Costs of data for Marine Strategy Framework Directive
3 Cost of data for offshore wind farms
4 Legal basis of Regulation or Directive
5 Innovation from marine data
6 Reductions in uncertainty
7 Options for governance of EMODNet.

A possible structure for the full impact assessment on an EU initiative on Marine Knowledge 2020 is shown below. We have marked the inputs that are provided by this study and where each of the seven components contributes. Hence, this report cannot be read as an impact assessment but as a study that provides input to several elements of an impact assessment.

Text box 1-1 Outline of impact assessment and the contribution from the current study

- *Problem definition and baseline: Lack of coordination of marine data*
  - ***Current use and sharing of data (1)***
- *Defining the objectives*
- *Options: Alternative measures to improve coordination and use of marine data*
  - ***Legal basis (4)***
  - ***Legal instrument (Regulation or Directive)(4)***
  - *Content of measures (Collection or Assembling)*
  - ***Organisation set-up (7)***
- *Impacts of options*
  - ***Reduced costs to data users (2, 3 and 4)***
  - ***Innovations (5)***
  - ***Reduced uncertainty (6)***
- *Comparison of options*

2 Marine data in the licensing process

2.1 Introduction

Commercial activities in marine and coastal aquaculture, renewable energy, minerals extraction, oil exploration and exploitation, port harbour and marina development and pipeline and cable laying are all subject to marine licences or permits.

This section covers two aspects of marine data in the licensing process:

› Private operators costs of purchasing marine data for their licence or permit applications.

When applying for such licences or permits, potential operators need bathymetric, metrological and hydrological data to use for modelling in connection with preparations of environmental impact assessments (EIAs) and environmental permits. Marine data used by operators in the preparation of licence or permit applications is either obtained from public authorities or other third parties or collected by the operators themselves. This component of the study aims at investigating whether operators pay for marine data obtained from public authorities and whether they would request more data if marine data were cheaper or easier to access.

› The obligations by private operators to hand over data gathered in relation to the licence/permit applications.

Besides the data obtained from public authorities operators also collect their own marine data for planning, developing and engaging in marine licensed activities. Such data collected by the private sector could be of use for public authorities in the Member States. A study on the "Use of industrial monitoring data for MSFD reporting purposes" by the European Commission found that many Member States wish to explore the use of industrial monitoring data, among others for data collection for the MSFD. Obligations for the private sector to disclose data collected and assembled in connection with licensed activities however differ across the European Union. This section therefore also aims at investigating to which extent such obligations exist in the Member States.

2.2 Facilitation of use of marine data

2.2.1 Private sector data collection

The inquiry about costs of publicly available marine data for licence applications focused on private operators in the seven marine sectors of aquaculture, renewable energy, minerals extraction, oil exploration and exploitation, port, harbour and marina development and pipeline and cable laying and covered questions 1 and 2 of the Terms of Reference.

The study started with the assumption that the degree to which operators have to pay for different types of data is likely to depend on the country and not on the sector and that the difference in data needs for licensing across sectors might imply that there is variation across sectors in costs for data. To cover all countries as well as all sectors the relevant European industry associations were contacted. The list below presents the contacted associations.

Table 2-1 Consulted industry associations

Stakeholder	Sector
Federation of European Aquaculture Producers (FEAP)	Aquaculture
European Wind Energy Association (EWEA)	Renewable Energy Cable and pipeline laying
European Aggregates Association (UEPG)	Minerals extraction
International Association of Oil & Gas producers (OGP)	Oil & gas exploration and exploitation Cable and pipeline laying
European Sea Ports Organisation (ESPO)	Port, harbour and marina development

The industry associations distributed the questionnaire among their members and collected the answers before submitting them to COWI/E&Y. The questionnaire covered questions 4a) through q) as well as an inquiry on potential economic benefits and innovation from improved marine knowledge.

2.2.2 Costs for marine data in licence applications (Question 1)

There seems to be no clear picture across the European Union regarding data costs to be borne by operators when preparing applications for marine licences or permits.

The answers to Question 1 of the Terms of Reference, namely whether operators pay for marine data when preparing their application for a licence, as presented below are based on inquiries sent to the licensing authorities in the Member States and to European Associations in the relevant marine sectors.

Of those countries that replied to the survey on data costs to licence applicants in about half potential operators in the seven marine sectors of aquaculture, renewable energy, minerals extraction, oil & gas exploration and exploitation, port, harbour & marina development and in cable and pipeline laying have to pay for meteorological, bathymetric and geological data when preparing applications for licences.

Table 2-2 Potential payment for bathymetric, metrological and hydrological by permit or licence applicants in selected Member States

Bulgaria	Licence applicants have to pay for marine data
Denmark	Licence applicants have to pay for marine data
Cyprus	Marine data free of charge (information from the ports sector)
France	Licence applicants have to pay for marine data (information from the ports sector in La Rochelle)
Germany	Licence applicants have to pay for marine data products, but not for data sets (information only available for renewable energy and cable and pipeline laying)
Norway	Licence applicants have to pay for marine data
Romania	Marine data free of charge (unless the marine data come from research institutions/agencies)
UK	Some marine data free of charge

Additionally to the Member States, answers regarding costs for marine data in licensing processes were received from the European Aggregates Association, the International Association of Oil and Gas Producers (OGP) and the European Sea Ports Organisation.

The European Aggregates Association reported that costs vary between Member States. However, in most countries operators pay for marine data and undertake additional studies for their licence applications. The text box below provides an example of the cost for bathymetric data from the British Geological Survey (BGS).

DigBath250

The British Geological Survey offers a vector attributed digital bathymetry of United Kingdom (UK) and adjacent European waters with a scale of 1:250000. Its purpose is to provide a regional scale digital bathymetry as a primary dataset for geographic information systems (GIS), mapping and modelling of the seabed and sub seabed. It may also be useful for regional scale tidal, current and water column modelling. It has been produced to a specification for non-navigation applications only. The cost of DigBath250 is 300 GBP per sector (North-West Scotland, Northern North Sea, Southern North Sea, English Channel, South West Approaches and Irish Sea).

According to the British Marine Aggregates Producers' Association (BMAPA), a minimum standard of prospecting survey investigation is defined as part of the tender process, including the need to obtain high quality data using a range of techniques. Seabed exploration is challenging, involving acoustic, seismic and seabed sampling techniques. The cost of surveying necessary for obtaining a marine licence, however, varies greatly between Member States and their specific regulations as well as between sites.

This finding was confirmed by the information provided by the International Association of Oil & Gas Producers. The OGP reported that it is very difficult to make a general statement regarding costs for marine data since much will depend on site to site factors and locations. However, meteorological, hydrographical, bathymetric and geological data compiled for the EIA do not look to represent a significant part of the EIA related costs. The precise ratio will also fluctuate from country to country depending on their domestic requirements and legislations.

The OGP also reported that the Oil and Gas Producers community already has an extensive experience on harmonising seabed data. The OGP has developed "Guidelines on Seabed Survey Data Model" that describe the Seabed Survey Data Model (SSDM), which is a specification used in the industry for handling the delivery of various seabed survey datasets in GIS data format.

The European Sea Ports Organisation (ESPO) provided replies from Bulgaria, Cyprus, Denmark and the port of La Rochelle in France. The answer from Bulgaria was received from the Bulgarian Ports Infrastructure Company, a state-owned ports infrastructure company. The Bulgarian Ports Infrastructure Company reported it does not pay for marine data that and that new port projects require an Environmental Impact Assessment to be prepared according to EU regulations. Repair, rehabilitations and modernizations require permits under the water act regulations of the Bulgarian legislation. In Denmark, marine data required for undertaking port development activities has to be acquired by operators, usually from consultancies and/or state owned institutions. Regarding Cyprus, the ESPO reported that operators of ports do not have to pay for marine data needed in relation to e.g. port development projects. The port of La Rochelle reported that marine data required for undertaking EIAs are provided by the consultants commissioned to undertake that assessment. Possible costs for collection and purchase of data are typically included in the overall price for the EIA.

2.2.3 Request for more marine data (Question 2)

Question 2 concerns the potential request for more data (i.e. higher resolution in time or space) if marine data were substantially cheaper or easier to access. Answers to this question were received from operators in the offshore wind, the minerals extraction and the oil exploration and exploitation sector via the respective industry associations.

Offshore wind operators reported that publicly available data are often not requested by operators because very specific data are not available and because the quality of the available data is not high enough. Generally the kind of data operators need for project development and impact assessment is not available from other sources, and therefore data are collected by operators in the context of the individual project. Only one operator reported that more data would be requested if data access was cheaper or easier.

The European Aggregates Association reported that companies often go beyond what is required in licensing conditions regarding marine data collection and produce high quality data during impact studies. Reduced costs for marine data acquired from public authorities would, however, be welcomed.

The International Association of Oil & Gas Producers reported that meteorological, hydrographical, bathymetric and geological data compiled for EIA does not represent a significant part of EIA related costs in the sector relative to overall EIA costs. As EIA procedures are lengthy and costly, the absolute costs for marine data are however high despite only representing a small share of overall costs.

Table 2-3 Possible requests for more data if they were cheaper or more easily available

Offshore wind	Publicly available data are often not requested by operators because very specific data are not available and because the quality of the available data is not high enough.
Minerals extraction	Companies are driven by acquiring the data necessary for the permits but, nevertheless, often go beyond what is required. In some cases, high quality data are produced by companies during impact studies. However, reduced costs of data available would be welcomed.
Oil exploration and exploitation	Meteorological, hydrographical, bathymetric and geological data compiled for the EIA do not look to represent a significant part of the EIA related costs. Absolute costs are, however, considerable.

2.3 Re-use of marine data assembled for undertaking licensed activities

2.3.1 Public Sector data collection

The inquiry on public sector re-use of data aimed at collecting answers to questions 3 to 5 of the Terms of Reference and focused on the competent licensing authorities in the Member States and in Croatia, Iceland and Norway.

Question 3 inquires about the obligation for handing over to public authorities marine data gathered in order to plan, develop or engage in licensed activities in the seven marine sectors. In case such obligations exist, the sub-questions under Question 4 inquire further into the details of this obligation. For those countries that do not oblige licence applicants and holders to hand over data, Question 5 inquires whether there are plans to introduce a data hand-over obligation.

To obtain a first overview of the existence of obligations to hand over data, an introductory survey was sent out to all licensing authorities. For those countries that reported that they do not have an obligation for handing over data, additional information was only gathered on potential plans to introduce such an obligation. The other countries received a follow-up questionnaire covering question 4 of the Terms of Reference. The table below presents the licensing authorities that were contacted through the questionnaires.

Table 2-4 Received responses to Questionnaire based survey in Member States (and Croatia, Iceland and Norway)

Stakeholder	Country	Response received
Management Unit of the North Sea Mathematical Models and the Scheldt estuary	BE	
Ministry of Economy, Energy and Tourism Executive Agency for Fisheries and Aquaculture Executive Agency Maritime Administration	BG	x
Department of Fisheries and Marine Research	CY	x
Danish Coastal Authority	DK	x
Centre for Economic Development, Transport and the Environment	FI	
Ministry of Ecology, Energy and Sustainable Development	FR	
Landesamt für Bergbau, Energie und Geologie, Lower Saxony	DE	x
Hellenic Ministry of Environment, Physical Planning & Public Works	EL	
Marine Environment Department	EE	x
Department of Environment, Community and Local Government	IE	(x)
Institute for Environmental Protection and Research	IT	
Environment protection division, Marine and Inland Waters Administration, State Environment Service	LV	x
Environmental Protection Agency	LT	
Malta Environment and Planning Authority	MT	
Ministry of Infrastructure and the Environment	NL	
Ministry of Infrastructure	PL	
Portuguese Environment Agency	PT	
National Institute for Marine Research and Development	RO	(x)
Ministry of Environment	SI	

Stakeholder	Country	Response received
Division for the Protection of the Sea, Ministry of Agriculture, Food and Environment	ES	x
Swedish Agency for Marine and Water Management	SE	
Welsh Government - Marine Consents Unit,	UK	
Marine Scotland	UK	(x)
Marine Management Organisation	UK	(x)
Department of Environment Northern Ireland, Marine Division	UK	x
Ministry of Environmental Protection and Nature	HR	x
National Energy Authority, Environment Agency	IS	x
Norwegian Hydrographic Service	NO	(x)

Please note: (x) means that only replies to the introduction survey were received

The answers to all questions in section 2.3 were received from the authorities listed above.

The selection of responses covers different Member States with regard to size, location and new or old Member States so they provide a reasonable representative sample.

2.3.2 Obligation to hand over marine data (Question 3)

Question 3 of the Terms of Reference inquires about the existence of obligations for operators to hand over to public authorities the data collected or acquired in order to plan, develop or engage in licensed activities. For those countries in which such an obligation exists, sub-questions 4a) to 4 q) further investigate the details of the hand-over obligation.

The table below presents an overview of the status in a number of Member States and Croatia, Iceland and Norway.

Table 2-5 Obligations to hand over data to public authorities by permit or licence applications

Bulgaria	Obligation to hand over data varies between sectors and phases of operations (siting, construction, operation)
Croatia	Obligation to hand over data
Cyprus	Obligation to hand over data in the aquaculture sector
Estonia	Extensive obligation to hand over data
England	No obligation to hand over data

Germany	Information only available for renewable energy and cable and pipeline laying: Obligation to hand over certain marine data
Iceland	Obligation to hand over data for all sectors
Ireland	Obligation to hand over data in aquaculture, renewable energy, minerals extraction, port, harbour and marina development and cable and pipeline laying
Latvia	Obligation to hand over data from monitoring activities for all sectors (Aquaculture n/a)
Northern Ireland	Information only available for renewable energy, mineral extraction, port, harbour and marina development and cable and pipeline laying: Obligation to hand over marine data
Norway	Obligation to hand over data (no information available for oil exploration and exploitation)
Romania	Obligation to hand over data (n/a for renewable energy and minerals extraction as there are no such offshore activities in Romania)
Scotland	No obligation to hand over data
Spain	No general obligation to hand over data

Source: Results of Member State survey

The conclusion is that in ten countries there is an obligation, at least in some sectors, while in the UK except for Northern Ireland and in Spain there is no such obligation.

2.3.3 Special circumstances (Question 4a)

Question 4a concerns special circumstances (e.g. closeness to marine protected areas or economic value of the activities) upon which the obligations to hand over data as inquired in Question 3 might depend.

In most countries, the obligation for operators to hand over marine data does not depend on any special circumstance other than the differences related to type of marine data presented in the next section.

Only Iceland report for example that for aquaculture "*requirements of data delivery are dependent on the size of the proposed project, existing aquaculture in the area and local circumstances*". They also report in relation to oil exploitation that "*Particulars of data to be turned over determined in EIA*"[21]. So generally it seems as they determine the specific requirements on a case by case basis.

[21] Reply to Questionnaire on licencing data requirements

2.3.4 Marine data concerned (Question 4b)

Question 4b aims at establishing an overview of the types of data concerned by the obligation to hand over marine data from licensed activities. For this purpose, COWI in its questionnaire on licensing practices in the public sector established 11 categories of marine data that might be concerned by the hand over obligation. These 11 categories are those most commonly needed for preparing Environmental Impact Assessments in the marine sector. Only licensing authorities from a certain number of countries were able to provide information on the exact type of data included in the obligation to hand over data. The table below presents the findings for those eight countries that provided details of the types of data concerned by the hand-over obligation. In those sectors/countries in which all marine data are concerned, no additional information is provided regarding the types of data required as all marine data collected according to the licence conditions needs to be handed over. For the countries/sectors for which the table specifies that not all marine data are concerned by the hand-over obligation the specific columns illustrate which data need to be handed over. The x) in the table indicates that the respective data have to be handed over.

A general finding based on the collected information is that in those countries that provided replies to the questionnaire there seems to be an extensive obligation to hand over data that depend on the sector/activity concerned.

Table 2-6 Obligation to hand over data by sector and type of data

		All marine data	Meteorological data	Oceanographic data	Water quality data	Bathymetric data	Sediment/geology data	Plankton data	Benthic vegetation data	Benthic fauna data	Fish data	Bird data	Marine mammal data
Aquaculture	Bulgaria	Yes											
Renewable Energy	Bulgaria	No	x		x			x			x	x	x
Minerals extraction	Bulgaria	No					x						
Oil exploration	Bulgaria	No					x						
Oil exploitation	Bulgaria	No					x						
Port, harbour and marina development	Bulgaria	Yes											
Aquaculture	Croatia	No	x	x	x	x	x	x	x	x	x		
Renewable Energy	Croatia	No	x		x		x					x	
Minerals extraction	Croatia	No	x	x	x		x					x	
Oil exploration	Croatia	No	x	x	x	x	x	x	x	x			
Oil exploitation	Croatia	No	x	x	x	x	x	x	x	x			
Port, harbour and marina development	Croatia	No	x	x	x	x	x	x	x	x			
Cable and pipeline laying	Croatia	No	x	x	x	x	x		x	x			
Aquaculture	Cyprus	No		x	x		x	x	x	x			

		All marine data	Meteorological data	Oceanographic data	Water quality data	Bathymetric data	Sediment/geology data	Plankton data	Benthic vegetation data	Benthic fauna data	Fish data	Bird data	Marine mammal data
Port, harbour and marina development	Estonia	No		x	x	x	x		x	x	x	x	
Aquaculture	Estonia	No			x								
Minerals extraction	Estonia	No		x	x	x			x	x	x		
Cable and pipeline laying	Estonia	No			x	x	x				x		
Renewable Energy	Germany	No					x			x	x	x	x
Cable and pipeline laying	Germany	No					x			x	x	x	x
Aquaculture	Iceland	No	x	x	x	x	x		x	x	x	x	x
Minerals extraction	Iceland	No		x		x	x	x	x	x	x		x
Oil exploration	Iceland	No	x	x	x	x	x	x	x	x	x	x	x
Oil exploitation	Iceland	No	x	x	x	x	x	x	x	x	x	x	x
Cable and pipeline laying	Iceland	No				x	x			x	x		
All sectors	Latvia	Yes											
Renewable Energy	N.Ireland	Yes											
Minerals extraction	N.Ireland	Yes											
Port, harbour and marina development	N.Ireland	Yes											
Cable and pipeline laying	N.Ireland	Yes											

Source: Results of Member State survey

2.3.5 Coverage of data acquired from third parties (Question 4c)

Question 4c aims at establishing an understanding of whether the obligation to hand over data only covers data collected by the project or also data acquired from third parties.

As the table below shows, the obligation to hand over data covers data acquired from third parties only in a few sectors in Bulgaria, Iceland and Northern Ireland.

Table 2-7 Obligation to hand over data acquired from third parties

Does the obligation cover data acquired from third parties?		
Bulgaria	Aquaculture	No
Bulgaria	Renewable Energy	No
Bulgaria	Minerals extraction	No
Bulgaria	Oil exploration	No
Bulgaria	Oil exploitation	No
Bulgaria	Port, harbour and marina development	Yes
Cyprus	Aquaculture	No
Estonia	All sectors	No
Germany	Renewable Energy	No
Germany	Cable and pipeline laying	No
Iceland	Aquaculture	No
Iceland	Minerals extraction	Yes
Iceland	Oil exploration	Yes
Iceland	Oil exploitation	Yes
Iceland	Cable and pipeline laying	No
Latvia	All sectors	No
N.Ireland	Renewable Energy	Yes
N.Ireland	Minerals extraction	Yes
N.Ireland	Port, harbour and marina development	Yes
N.Ireland	Cable and pipeline laying	Yes

Source: Results of Member State survey

2.3.6 Coverage of project phases (Question 4d)

Question 4d inquired into the coverage of the different project phases by the obligation to hand over data. The assumption of the questionnaire designed to gather information on this question was that there are differences in the coverage of project phases not only across countries, but also across sectors.

As presented in the table below, the answers received confirmed this assumption. In Croatia, Estonia, Germany and Northern Ireland, the obligation covers activities in all phases in all of the relevant marine sectors. In Bulgaria and Iceland, however, there are big differences across sectors regarding the hand-over of information from different project phases.

Table 2-8 Obligation to hand over data by project phase

Obligation covers:		Siting	Design	Construction	Operation
Bulgaria	Aquaculture				x
Bulgaria	Renewable Energy		x		x
Bulgaria	Minerals extraction	x	x	x	x
Bulgaria	Oil exploration	x	x	x	x
Bulgaria	Oil exploitation	x	x	x	x
Bulgaria	Port, harbour and marina development		x	x	x

Obligation covers:		Siting	Design	Construction	Operation
Croatia	All sectors	x	x	x	x
Cyprus	Aquaculture	x	x	x	x
Estonia	All sectors	x	x	x	x
Germany	Renewable Energy	x	x	x	x
Germany	Cable and pipeline laying	x	x	x	x
Iceland	Minerals extraction	x			x
Iceland	Oil exploration	x	x	x	x
Iceland	Oil exploitation	x	x	x	x
Iceland	Cable and pipeline laying	x			
N.Ireland	Renewable Energy	x	x	x	x
N.Ireland	Minerals extraction	x	x	x	x
N.Ireland	Port, harbour and marina development	x	x	x	x
N.Ireland	Cable and pipeline laying	x	x	x	x

Source: Results of Member State survey

2.3.7 Legal bases for obligations (Questions 4e, 4f)

Questions 4e and 4f inquire into the legal bases for the obligation to hand over marine data from licensed activities. The table below provides an overview of the legal basis in the seven countries that provided information on it.

Table 2-9 Legal basis for obligation to hand over data

What is the legal basis for the obligation?		
Bulgaria	Aquaculture	Council Regulation (EC) No 199/2008 and Council Regulation (EC) No 861/2006
Bulgaria	Renewable Energy	Environmental protection Act, Protected areas Act, Waters act, Biodiversity Act and related environmental legislation
Bulgaria	Minerals extraction	Subsurface Resources Act
Bulgaria	Oil exploration	
Bulgaria	Oil exploitation	
Bulgaria	Port, harbour and marina development	Law on the maritime spaces, inland waterways and ports of the Republic of Bulgaria; Regulation on the requirements for port operational suitability and Regulation on the scope and content of master plans for port development.
Cyprus	Aquaculture	National Aquaculture Law and Regulations 2010.
Estonia		Water Act, Maritime Safety Act; Other relevant legal acts regulating data acquisition: Environmental Impact Assessment and Environmental Management System Act; Integrated Pollution Prevention and Control Act; Environmental Register Act; Public Information Act
Germany	Renewable Energy	The legal basis of the obligation to hand over data and information is given by the Environmental Impact assessment Act and is part of the licensing conditions by BSH.
Germany	Cable and pipeline laying	
Iceland	Aquaculture	Environmental Impact Assessment Act, Hygienic and Pollution Act, Act on Prevention of Marine and Coastal Pollution

What is the legal basis for the obligation?		
Iceland	Minerals extraction	For EIAs the Environmental Impact Assessment Act No. 106/2000 and for license applications the Act on Icelandic National Ownership of Seabed Resources No. 73/1990, outside the netting limits, i.e. 115 metres from the Mean Low Water Springs, and the Act on the survey and utilisation of ground resources No. 57/1998, within netting limits.
Iceland	Oil exploration	Act on prospecting, exploration and production of hydrocarbons No. 13/2001, see the link: http://www.nea.is/media/olia/Act-No-13-2001-03102011.pdf
Iceland	Oil exploitation	
Iceland	Cable and pipeline laying	Environmental Impact Assessment Act, Hygienic and Pollution Act, Act on Prevention of Marine and Coastal Pollution
Latvia		Environmental Protection Law; Law of On Environmental Impact Assessment; Cabinet Regulation No. 1082 "Procedure by Which Polluting Activities of Category A, B and C Shall Be Declared and Permits for the Performance of Category A and B Polluting Activities Shall Be Issued"; Cabinet Regulation No. 595 "Regulations regarding the Protection of the Environment during the Works of Exploration and Extraction of Hydrocarbons in the Sea"; Cabinet Regulation Nr.475 "Procedures for the cleaning and deepening of surface water bodies and port basins"
N.Ireland	Renewable Energy	Marine and Coastal Access Act 2009, Part 4 Marine licensing
N.Ireland	Minerals extraction	
N.Ireland	Port, harbour and marina development	
N.Ireland	Cable and pipeline laying	

Source: Results of Member State survey

Additionally to the information provided above, the table below shows to which extent the legal bases cover the entire national territories. The coverage of regulations typically concerns all national territory. In the case of the renewable sector in Bulgaria and renewable and cable and pipeline laying in Germany, the specific requirements for data hand-over are dependent on the respective region in which the marine activities are based.

Table 2-10 Possible variations in the legal obligation across national territories

Does the legal basis cover all national territory in the same way?		
Bulgaria	Aquaculture	Yes
Bulgaria	Renewable Energy	There are specific requirements depending on the specific of the regions
Bulgaria	Minerals extraction	Yes
Bulgaria	Oil exploration	Yes
Bulgaria	Oil exploitation	Yes
Bulgaria	Port, harbour and marina development	Yes

Does the legal basis cover all national territory in the same way?		
Croatia		Yes
Cyprus	Aquaculture	Yes
Germany	Renewable Energy	The legal base is the same, but in Germany the obligations and conditions for handing over data may vary among the licensing authorities with responsibilities in the EEZ and in territorial sea.
Germany	Cable and pipeline laying	
Iceland	Aquaculture	Legal requirements cover land, territorial sea and EEZ.
Iceland	Minerals extraction	The Act on Icelandic National Ownership of Seabed Resources No. 73/1990 covers resources on, into or beneath the seabed outside the netting limits, i.e. 115 metres from the Mean Low Water Springs. The Act on the survey and utilisation of ground resources No. 57/1998 covers resources in the ground, at the bottom of rivers and lakes and on seabed within netting limits.
Iceland	Oil exploration	Covers offshore area (outside the 115 m zone), i.e. territorial waters, exclusive economic zone and continental shelf.
Iceland	Oil exploitation	
Iceland	Cable and pipeline laying	Legal requirements cover land, territorial sea and EEZ.
Latvia		Yes
N.Ireland	Renewable Energy	Yes
N.Ireland	Minerals extraction	
N.Ireland	Port, harbour and marina development	
N.Ireland	Cable and pipeline laying	

Source: Results of Member State survey

2.3.8 Plans to modify obligations (Question 4g)

Question 4g inquires whether there are plans to modify the obligations and legal bases for handing over marine data.

In most countries, there are no plans to modify the legal obligation to hand over marine data from licensed activities. The only countries that communicated plans to change their obligation are Bulgaria where only the port, harbour and marina sector is concerned and Estonia where there they currently are investigating whether the burden on companies can be reduced and the results of that assessment could lead to modification or change in the obligation to hand over data.

Table 2-11 Plans to modify the legal obligation to hand over data

Are there plans to modify the obligation?		
Bulgaria	Port, harbour and marina development	Yes, there are plans to simplify this obligation, but still in compliance with the EU legislation in force.
Croatia		No
Estonia		Development projects of information systems for permitting and reporting are on-going to reduce the burdens for enterprises on permit application, reporting (monitoring, fees and taxes) and later data management. After the finalization of the abovementioned project KESE, it might be necessary to modify the data input and output forms for different users.
Germany	Renewable Energy	Not to our knowledge.
Germany	Cable and pipeline laying	
Iceland		No
Latvia		No
N.Ireland		Not in the near future.

Source: Results of Member State survey

2.3.9 Data transfer (Questions 4h, 4i, 4j)

Questions 4h, 4i and4 j inquire into the details of the transfer of data from licence holders to public authorities. While there often seem to be no general timetables according to which data need to be transferred, a yearly or half-yearly data report seems to be common. In many of the reported cases, the timeframe according to which data are to be transferred is stated in the licensing agreement.

Regarding the format according to which data need to be transferred, there seems to be no consistency across countries and sectors. Only Germany and Estonia reported that (meta-) data are consistent with the INSPIRE guidelines

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Table 2-12 Requirements on data transfer regarding time table, format and consistency with INSPIRE

Do the data need to be transferrred to any particular				
Timetable?			Format?	Format consistent with INSPIRE?
Bulgaria	Aquaculture	Yes. Collection of the Information for the current year shall be made in the next.	Defined in Council Regulation EC/199/2008 , Council Regulation EC/861/2006 and DCR appendixes I to XIX	We have no information on whether the data comply with INSPIRE.
Bulgaria	Renewable Energy	1) For availability and estimated potential resource data: before concludion agreement for access with an operator of the transmission or the distribution electricity grid 2) For the other marine data: during the operational period		
Bulgaria	Minerals extraction, oil exploration & exploitation	Within a time period: upon a contractual agreement.		
Bulgaria	Port, harbour and marina development	No particular timetable; the transfer of data is regulated by legislation which allows certain flexibility		
Croatia		No		
Cyprus	Aquaculture	Obligation to send to the Department of Fisheries and Marine Research of Cyprus (DFMR), twice a year, monitoring reports according to the impact in the marine environment		
Estonia		Yes, different activities have different timetables for data transferring.	Monitoring data are site-specific, i.e. coordinates of the monitoring sites are included into the permit as well as later into the reports (consistent with INSPIRE).	Yes
Germany	Renewable Energy and Cable and pipeline laying	The deadlines for data and information submission are set by the licensing authority. Deadlines may depend on the project-phase as well as on the project- and area specific characteristics.	The licensing authority BSH specifies the requirements dealing with data formats. These requirements are published on webpage of BSH.	Metadata information complies as far as possible with existing guidelines of INSPIRE for the marine sector.
Iceland	Aquaculture	No	Not specified. GIS coordinates are generally required.	
Iceland	Minerals extraction	Operators are obliged to hand over data for EIA according to particular timetable, based on chapters III and IV in the Environmental Impact Assessment Act No. 106/2000, see the link: http://www.skipulagsstofnun.is/media/pdf-skjol/MAUlogm2005br.pdf	Most of the data for EIA and license applications are hand over at paper format (reports), but small part at CD ROM.	This format is not consistent with INSPIRE.
Iceland	Oil exploration & exploitation	Minimally a yearly report. Timetable to be determined in EIA.	Has not been decided.	The goal is that it will be consistent with INSPIRE.
Iceland	Cable and pipeline laying	No	Not specified. GIS coordinates are generally required.	
Latvia		Timetable for data application is included in permit or licence. Monitoring program for disposal places of dredged material from ports requires providing the data once every season (4 times a year).	Information format for data application is included in permit or licence.	
N.Ireland		No particular timetable in general but monitoring activities may have time bounded conditions.		Not all data supplied is in a format that is consistent with INSPIRE, some would need to be

Source: Results of Member State survey

2.3.10 Management of data in public authorities (Question 4k)

The table below presents an overview of the authorities responsible for the management of handed-over data in response to question 4k. In most cases the responsible public authority is the licensing authority.

Table 2-13 Public authorities management of data handed over by permit and licence holders

Who manages the data one in has been passed to a public authority?		
Bulgaria	Aquaculture	National Agency of Fisheries and Aquaculture (NAFA)
Bulgaria	Renewable Energy	Ministry of regional development and public works and Ministry of Environment and Waters
Bulgaria	Minerals extraction, Oil exploration & exploitation	National Geological Fund, Directorate National Resources and Concessions, Ministry of Economy, Energy and Tourism
Bulgaria	Port, harbour and marina development	The Bulgarian Maritime administration manages the handed over data.
Cyprus	Aquaculture	The Department of Fisheries and Marine Research (DFMR) makes an assessment of submitted reports and no data management.
Estonia		Environmental Board – issuer of the permits and all the reporting from permits is handed over to EB, Estonian Environment Information Centre – manages data and environmental register, Estonian Maritime Administration
Germany	Renewable Energy	Data sampled by licensees of renewable energy, cables and pipelines in the German EEZ are managed by the licensing authority BSH. Still, it should be strictly distinguished between two basic classes of data: › data and information in form of EIA reports and technical reports with data tables of analysed data in annexes › raw-data, quality proved data, metadata, extracted and analysed data, comprehensive data tables and GIS-layers.
Germany	Cable and pipeline laying	
Iceland	Aquaculture	The relevant licensor (party issuing the relevant license).
Iceland	Minerals extraction	The handed over data are filed in the Orkustofnun's archive system and the archive administrator is responsible for the system and the manager of mineral resources is responsible for the data.
Iceland	Oil exploration	Orkustofnun responsible for managing all geological data. Various other institutes responsible for other data depending on field, e.g. Marine Research Institute, Iceland Maritime Authority, Environmental Agency of Iceland, etc.
Iceland	Oil exploitation	
Iceland	Cable and pipeline laying	The relevant licensor (party issuing the relevant license).
Latvia		Data from licensed activities are handled by State Environmental Service and Latvian Environmental, Geological and Meteorological Centre.
N.Ireland	Renewable Energy	The Marine Assessment and Licensing Team of Northern Ireland Environment Agency.
N.Ireland	Minerals extraction	
N.Ireland	Port, harbour and marina development	
N.Ireland	Cable and pipeline laying	

Source: Results of Member State survey

2.3.11 Restrictions on re-use (Question 4l)

Question 4l inquires about possible restrictions placed on the re-use of marine data handed over from operators to public authorities, i.e. whether there are any distinctions made between academic use, public authority use and commercial use.

A general conclusion that can be drawn from the received answers is that in most countries and sectors there are no general restrictions placed on the re-use of data. Usually, only data that are commercially confidential cannot be re-used.

Table 2-14 Restrictions on the re-use of handed-over data

Are there any restrictions on the re-use of data?		
Bulgaria	Aquaculture	No
Bulgaria	Minerals extraction	There is restriction for information, handed by licensees with activities in exploration and exploitation. This data are considered a property of and are handed over by the Ministry of Economy, Energy and Tourism with their consent and agreement
Bulgaria	Oil exploration	
Bulgaria	Oil exploitation	
Bulgaria	Port, harbour and marina development	The re-use of these data which are trade secret is restricted, regulated under the Law on the access to public information.
Croatia		No
Cyprus	Aquaculture	The reports (data) are not being reused for a different purpose by the Department of Fisheries and Marine Research.
Estonia		Generally data and information have no restrictions and are available for everyone. But specific and detailed information might not be publicly available. Restrictions on data publicity are given in the Public Information Act (ie data on protected species or their habitats, proprietary information etc.)
Germany	Renewable Energy	Data and information handed over by licensees of offshore uses are declared as commercial and trade secrets of the companies. This is not applicable for all information which has been published in the framework of public participation in the licensing procedure.
Germany	Cable and pipeline laying	
Iceland	Aquaculture	Data delivered to public authorities are generally publicly available, unless specially notified as "confidential".
Iceland	Minerals extraction	The handed over data in the license application papers are open for re-use at the Orkustofnun's website http://www.os.is, but if you need the basic data from the applicant database, it will be necessary to have permission from the applicant. It is also common that government research institutes, as the Marine Research Institute, write an overview research report for the applicant, based on the institute's database, which is open for public use.
Iceland	Oil exploration and exploitation	Depends on nature of data involved. Proprietary data to be handled confidentially by Orkustofnun for a certain period prior to opening, but can use data internally. Environmental data may be released to public as a part of monitoring in situ conditions.
Iceland	Cable and pipeline laying	Data delivered to public authorities are generally publicly available, unless specially notified as "confidential".
Latvia		Environmental Protection Law (21 June 2007) Section 7. Rights of the Public to Environmental Information (1) The public has the right to receive environmental information from the authorities (..) in a written, audio, visual, electronic or any other form. (3) The applicant that requests environmental information shall not have to justify for what purposes this information is necessary. Section 11: "Procedures for the Issuance of Environmental Information, Time Periods and Charge for the Issuance Thereof": (4) The receipt of environmental information may be limited only in the cases specified by the Law in accordance with the procedures specified in the Freedom of Information Law.
N.Ireland	Renewable Energy	No restrictions on re-use unless a prior case for commercial in confidence has been accepted.
N.Ireland	Minerals extraction	
N.Ireland	Port, harbour and marina development	
N.Ireland	Cable and pipeline laying	

Source: Results of Member State survey

2.3.12 Availability of data and feedback by users (Questions 4m, 4n)

Questions 4m and 4n inquire into the availability of marine data for re-use and into the feedback provided by users.

In most countries and sectors, marine data are made available upon request. However, some countries also publish some of their marine data on the internet, either through their own websites or e.g. on the website of the Joint Research Centre of the European Commission (for the case of aquaculture data from Bulgaria).

Table 2-15 Availability of handed-over data

How are data made available?		
Bulgaria	Aquaculture	On the web site of Joint Research Centre (JRC), EC.
Bulgaria	Renewable Energy	A written request
Bulgaria	Minerals extraction	For access to the data a written request to the Ministry of Economy, Energy and Tourism is needed
Bulgaria	Oil exploration	
Bulgaria	Oil exploitation	
Bulgaria	Port, harbour and marina development	By request
Croatia		By request
Estonia		Both, by request and through Internet.
Germany	Renewable Energy	The licensing authority may make information available upon request based on the conditions by the Freedom of Information Act or Environmental Information Act. The information depending on the subject may be available either as a technical report, GIS-layer or compact tables. Some standard products (like GIS-layers) are developed by experts in the framework of assessment-projects ordered by the licensing authority.
Germany	Cable and pipeline laying	
Iceland	Aquaculture	Generally by request. However, there is a trend towards making data available on the internet.
Iceland	Minerals extraction	The handed over data in the license application papers are available for re-use through the Orkustofnun's website: http://www.os.is.
Iceland	Oil exploration	By request, on the Orkustofnun's websites: http://www.os.is and http://www.nea.is, and through the online Iceland Continental Shelf Portal, http://www.icsp.is
Iceland	Oil exploitation	
Iceland	Cable and pipeline laying	Generally by request. However, there is a trend towards making data available on the internet.
Latvia		Information will be available through Internet and/or in the form or format indicated in the request for information.
N.Ireland	Renewable Energy	By request.
N.Ireland	Minerals extraction	
N.Ireland	Port, harbour and marina development	

How are data made available?		
N.Ireland	Cable and pipeline laying	

Source: Results of Member State survey

The next table reports on the feedback by users.

Table 2-16 Feedback by users of data

What feedback has been provided by users?		
Bulgaria	Aquaculture	All the variables and the data are aggregated. Collecting information about number of enterprises, quantity of fish, turnover for the year, subsidies, other revenue, total income, wages, value of unpaid labor, energy costs, raw material costs, repair and maintenance, other operating costs, interest costs, net financial costs, unforeseen costs, total assets, investment, capital, debt at the end of fiscal year, volume of raw materials.
Bulgaria	Minerals extraction	Feedback has been received and it differs according to the data, but mostly it is positive.
Bulgaria	Oil exploration	
Bulgaria	Oil exploitation	
Estonia		Currently we are carrying out an environmental monitoring data survey project (project KESE) about usage, availability and quality of all monitoring data. So far all the permits conditions and state environmental monitoring data are available to the public. Main concerns have been that information is hard to find, is in inappropriate form for the user, doesn't contain all necessary or relevant data, info is too general in order to solve local problems. Also the lack of most recent data has been mentioned sometimes.
Germany	Renewable Energy	The data and information is used by authorities and scientists with positive feedback.
Germany	Cable and pipeline laying	
Iceland	Minerals extraction	Orkustofnun has received feedback on the data from the public. The feedback is positive for the open data from licensed activities on the Orkustofnun's website: http://www.os.is.
Iceland	Oil exploration	Geological information provided by Orkustofnun, e.g. in the Iceland Continental Shelf Portal has been positively received by users.
Latvia		There are no offshore activities (excepting dumping of dredged material) in the territorial sea and EEZ of Latvia for the time being. Therefore only data from dumping places of dredged material has been provided (sediment sampling and measurements of content of heavy metals (Cu, Cd, Ni, Zn, Pb, Cr, Hg), oil products, macrozoobentos). There were no requests for this information.

Source: Results of Member State survey

2.3.13 Exceptions for SMEs (Question 4o)

Question 4o inquired into possible exceptions for SMEs from the obligation to hand over marine data from licensed activities.

Only Iceland reported the existence of such exceptions in two sectors, namely the aquaculture and the minerals extraction sector. In both sectors, there are exceptions for smaller projects in the licence procedures and the obligation to hand over data. In all other sectors and countries, there are no exceptions for SMEs.

Table 2-17 Possible differences in the obligation to hand over data for SMEs

Are there any exceptions for SMEs?		
Bulgaria	Aquaculture	No
Bulgaria	Minerals extraction	No
Bulgaria	Oil exploration	No
Bulgaria	Oil exploitation	No
Bulgaria	Port, harbour and marina development	There are no exceptions for SMEs but the procedure for marina development is considerably simpler compared to port and harbour development procedure.
Croatia		No
Estonia		No exceptions for SMEs; large enterprises must have an integrated permit (IPPC) and deliver their data according to the permit.
Germany	Renewable Energy	No exceptions in the German EEZ. General statement: Projects in German coastal water may have other obligations depending on the licensing authority of the federal state like Niedersachsen, Schleswig-Holstein and Mecklenburg-Vorpommern.
Germany	Cable and pipeline laying	
Iceland	Aquaculture	Yes, small aquaculture projects (less than 200 tonnes/year) are subject to less requirements and simpler license procedures.
Iceland	Minerals extraction	Yes, there are some exceptions for smaller projects, both in handing over data for EIA and for license applications.
Iceland	Oil exploration	No exceptions all licensees have to fulfil all requirements, involves deep, offshore drilling.
Iceland	Oil exploitation	
Latvia		No
N.Ireland	Renewable Energy	No
N.Ireland	Minerals extraction	
N.Ireland	Port, harbour and marina development	
N.Ireland	Cable and pipeline laying	

Source: Results of Member State survey

2.3.14 Burdens and costs (Questions 4p, 4q)

Question 4p inquires into the burdens and costs connected with the obligation to hand over marine data.

Regarding burdens on private operators in connection with the obligation to hand over marine data from licensed activities, answers from five countries were received. There seems to be no general answer to the question whether burdens exist.

Northern Ireland reported that anecdotally larger operators find it easier to collect and hand over data than small operators. Iceland reported that in the oil sector there are burdens connected to the requirements of the Hydrocarbons Act and licences but that these burdens are accepted part of the business. Bulgaria reported burdens in the aquaculture and port, harbour and marina development sector.

Table 2-18 How burdensome is it to comply with the obligation to hand over data?

Is it burdensome to comply with the legislation?		
Bulgaria	Aquaculture	Yes. It is burdensome for operators to comply whit the obligation to hand over the data.
Bulgaria	Renewable Energy	The date collection is from other institutions and organisations – No information for burdens
Bulgaria	Minerals extraction	No burdens
Bulgaria	Oil exploration	No burdens
Bulgaria	Oil exploitation	No burdens
Bulgaria	Port, harbour and marina development	Yes, it is burdensome with regards to the environmental impact assessment.
Estonia		It might be burdensome (e.g. high costs of different activities) to carry out data collection activities (monitoring). But once it is done, it is not so burdensome to hand over the data.
Germany	Renewable Energy	It is definitely burdensome for operators of offshore facilities to hand over data to fulfil responsibilities in the licensing procedure. The main issue is to distinguish between data sampled for impact assessments and data sampled in the frame of national monitoring activities: - All investigations for impact assessments of offshore projects in the German EEZ are carried out according to standard procedures. The standard procedures take into account the specific purpose of the studies regarding spatial design, frequency of sampling and observations and data analysis methods. Otherwise the licensing authority is not in the state to decide on the project application. - Since an operable national monitoring programme exists data from licenses may be used to some extend additionally to gain some specific indications on effects of uses and facilities or even to fill investigation and data gaps of the national monitoring.
Germany	Cable and pipeline laying	
Iceland	Aquaculture	Requirements are highly variable according to the size of projects, locations and conditions. Additionally, much of the information is needed by the operators for their own purposes. The answer to this question is therefore highly dependent on the operator and the nature of the project.
Iceland	Minerals extraction	It isn't burdensome for operators.
Iceland	Oil exploration	To ensure public safety and the safety of the environment the operators have to fulfil all requirements of Hydrocarbons Act and license. This is burdensome but accepted part of the business.
Iceland	Oil exploitation	
N.Ireland	Renewable Energy	Anecdotally larger operat0ors find it easier to collate and hand over data.
N.Ireland	Minerals extraction	
N.Ireland	Port, harbour and marina development	

Is it burdensome to comply with the legislation?		
N.Ireland	Cable and pipeline laying	

Source: Results of Member State survey

Question 4q aimed at gaining an overview of the costs incurred by the licensee in provision of the data and the public authority in the management of the data. The answers received by the six countries that provided information on this question should be considered with some caution. While most respondents were not able to quantify the costs incurred by licensees and licensers, Bulgaria reported costs of EUR 100,000 yearly and Cyprus costs of EUR 5,000 per monitoring report in the aquaculture sector. Since the source of these figures and the underlying assumptions are not known, these figures should be taken very cautiously. For the oil sector, Iceland reported a yearly fee of ISK 1,000,000 (~ EUR 6,100) to be paid by licensees for the management of data. Additionally to this, licensees pay the costs of collecting and providing data to the licensing authority. In the other countries and sectors, the costs for both public authorities and licensees are not known.

Table 2-19 Costs to permit and licence holders in relation to the hand-over obligation

What are the costs incurred by the licensee in provision of the data and the public authority in the management of data?		
Bulgaria	Aquaculture	The total costs are 100 000 euro yearly.
Bulgaria	Renewable Energy	These costs are not calculated
Bulgaria	Minerals extraction	
Bulgaria	Oil exploration	
Bulgaria	Oil exploitation	
Bulgaria	Port, harbour and marina development	Licensees incur direct costs related to the data
Cyprus	Aquaculture	Each monitoring report costs the licensees around € 5,000. The cost to the public authority in assessing the reports is about 3 man hours per report.
Estonia		Handing over data to public authority is free of charge. The costs for licensee are related to working hours for fulfilling the reporting forms. Reporting is done via Internet (no major costs) or by ordinary mail. Data management by the public authority is covered by state budget – personnel for controlling the data, input to the database, management and maintenance of the database as well as soft- and hardware costs.
Germany	Renewable Energy	The costs of data sampling, data analyses and preparing of reports for the authorities are high and covered by the licensees. The costs include i.e. ship and plane capacities for offshore surveys, scientists and technicians, data analysts. Additional costs for further scientific analysis and products are covered by the licensing authority in the frame of assessing project applications dealing with issues of concern, i.e. sound emissions, benthos. Standard products (GIS-layers) or technical reports of the assessments are then available for further scientific and public use. Specific requirements on products and reports may be available depending on the issue of concern, the costs and the priority of the issue.
Germany	Cable and pipeline laying	

What are the costs incurred by the licensee in provision of the data and the public authority in the management of data?		
Iceland	Minerals extraction	The licensees incur no costs when providing data to the public authority.
Iceland	Oil exploration	Each licensee pays 1.000.000 ISK yearly to Orkustofnun for managing data. Cost by licensee of providing data is not known, but they are required by the license to bear that cost.
Iceland	Oil exploitation	
N.Ireland	Renewable Energy	Unable to estimate licensee's costs or public authorities costs.
N.Ireland	Minerals extraction	
N.Ireland	Port, harbour and marina development	
N.Ireland	Cable and pipeline laying	

Source: Results of Member State survey

The answers to the questions about the obligations to hand over data have indicated many different practises across Member States.

3 Cost of data for Marine Strategy Framework Directive

3.1 Introduction

The Marine Strategy Framework Directive (MSFD) includes a number of requirements where there is need for collection of marine data.

The table below presents the reporting requirements of the Member States under the MSFD. They all require data to be collected and analysed.

Reporting requirement	Deadline
Initial assessment report	15th October 2012
Determination of Good Environmental Status (GES)	15 October 2012
Establishment of environmental targets and associated indicators	15 October 2012
Establishment and implementation of a monitoring programme for ongoing assessment and regular updating of targets	15 July 2014
Programme of measures designed to achieve or maintain Good Environmental Status	2015
Entry into operation of the programme to achieve or maintain GES	2016
Interim report on the implementation of the programme of measures	Every 3 years

The Member States are currently in the process of finishing the first assessment on the Marine Strategy Framework Directive that was due on the 15 October 2012 and that includes a mapping of the current marine status and reporting on the indicators in a set of reporting sheets.

The initial assessment report of the Member States will be delivered together with a report on the determination of Good Environmental Status and a report establishing environmental targets and associated indicators.

Concerning the effort and costs of the initial assessment, the respective competent authorities should hence have a good understanding of the data gaps and experienced costs. For the next elements in the MSFD, setting up additional monitoring programmes and other data collection for developing the programmes of measures to achieve compliance with GES, Member States have not necessarily yet defined the necessary data collection activities.

In addition, the necessary data are largely based on existing marine surveying and monitoring activities. Therefore, the estimation of the future resources to be spent on the MSFD is subject to some uncertainty.

3.2 Questionnaire based survey

The collection of information regarding data costs for the Marine Strategy Framework Directive was based on a questionnaire that was submitted to the national representatives in the EU coastal Member States and Croatia through the Working Group on Data, Information and Knowledge Exchange (DIKE). On 30 October 2012, COWI furthermore presented the questionnaire at the 6th meeting of the WG on Data, Information and Knowledge Exchange that was held in joint session with the Marine Observation and Data Expert Group.

The questionnaire was structured in three parts and contained a survey on the data used for the initial assessment and reporting, on future data collection and on data gaps. The questionnaire replies are based on estimates from the relevant Member State Competent Authorities. Though they are not "official" data on the costs, they represent the best estimates from the relevant authorities. It was often mentioned in the replies that separating out the MSFD costs was difficult and hence the estimates are subject to some uncertainty.

3.3 Results

The results obtained in relation to costs of data for the Marine Strategy Framework Directive are presented in four sections. Section 3.3.1 gives an overview of the costs for the initial reporting under the MSFD in a number of Member States. Section 3.3.2 provides answers to the question of effort to be spent by Member States until 2020, and sections 3.3.3 and 3.3.4 provide additional insights into the split of costs between existing and new monitoring/surveying programmes.

3.3.1 Efforts for MSFD initial assessment

According to the requirements of the Marine Strategy Framework Directive the Member States are obliged to make an initial assessment of their marine waters to be used for establishing a set of characteristics for Good Environmental Status and a comprehensive set of environmental targets to achieving Good Environmental Status.

For this initial assessment Member States either used existing marine data or collected additional new data. The table below shows the costs for assembling and reporting marine data under the initial assessment of the MSFD for 10 Member States.

Table 3-1 Reported MSFD implementation costs up to now

	Assembly of existing data		Collection of new data			
	Public authority staff costs	Contracted work by research institutes	Public authority staff costs	Contracted work by research institutes	Reporting of data	Total MSFD implementation costs up to now
1						700.000 €
2	3 man years (estimate)	250.000 (estimate)	0,3 my/year (project management)	1.000.000 per year	Public authority staff costs: 0,8 my (estimate) Contracted work by research institutes: 25.000 (estimate)	1.460.000 €
3						1.385.000 €
4						145.000 €
5						571.574 €
6	0 (No new staff has been hired)	660.000 €	0 (No new staff has been hired)	60.000 €	240.000 €	960.000 €
7	815.000 €	815.000 €			465.000 €	2.095.000 €
8						112.400 €
9						12.000.000 €
10	4 persons per year			3.300.000 €		3.560.000 €

Source: Member State Questionnaire replies

The Member States reported costs in both EUR and man-months. In order to allow comparability of the reported costs, the man-months have been converted to EUR using EU MS average hourly income from 2010. Costs were then adjusted using the Member States' GDP levels (PPP) from 2011 in order to account for differences in GDP levels across Europe[22].

Table 3-2 Adjusted MSFD implementation costs up to now

Countries	Reported MSFD implementation costs up to now	GDP adjusted implementation costs to now	Labour cost adjusted implemenation costs to now
1	700,000 €	853,659 €	889,474 €
2	1,460,000 €	1,168,000 €	878,078 €
3	1,385,000 €	1,398,990 €	1,648,345 €
4	145,000 €	216,418 €	480,490 €
5	571,574 €	1,270,164 €	4,829,800 €
6	960,000 €	1,476,923 €	2,351,304 €
7	2,095,000 €	1,662,698 €	1,469,108 €
8	112,400 €	135,422 €	204,254 €
9	12,000,000 €	9,160,305 €	9,703,349 €
10	3,560,000 €	3,327,103 €	2,759,817 €

Source: Member State Questionnaire replies

[22] Data on GDP price levels and hourly salary rates are from Eurostat

As an alternative to the GDP adjustment, the study furthermore explored the adjustment of reported costs on the basis of labour costs (EU Hourly Earnings adjusted to 2010 + Non-wage Labour Costs + 25% Overhead for Professionals) in the Member States. This calculation was made based on the assumption that most costs in relation to the MSFD initial assessment were costs for labour. Using labour costs to adjust reported costs leads to costs that are more equal between the different Member States and which might show a more realistic picture of the effort undertaken for the initial assessment.

Despite the conversion of costs, the replies are, however, not easy to compare. County one only reported costs of work contracted to research institutes. Also for the second country, the total costs only include contracted work. The estimates for public authority staff efforts (3 man years for assembly of existing data, 0.3 years for collection of new data and 0.8 years for data reporting), however, give an indication of the efforts of the concerned public authorities. The figure for country three also only includes the costs of contracts with public research institutions and private consultants (for the period 2010-2012) and no public authority staff costs. For the figures for countries four and five, it is not clear whether public authority staff costs are included or not. The figure for country six does not include public authority staff costs since no new staff was hired for the initial assessment and costs for the staff occupied with the assessment is not known. In country seven, only existing data were used for the initial reporting, and as such there are no costs reported for the collection of new data. For country 8, the figures include only public authority staff costs (no overheads) in the relevant ministry and include costs associated with the compilation of MSFD relevant data. Country 9 reported costs in relation to the MSFD implementation between 2007 and 2012 that amounted to EUR 12 million. Country 10 listed costs that occurred in marine research institutes with collecting data and drafting the initial assessment. The reported figure of EUR 3.3 million plus 4 man-years, however, does not include internal costs in the marine institutes and the necessary work for the initial assessment.

Based on the cost estimates received from 10 Member States, the study aimed at calculating an estimate for total EU costs for the initial assessment. In order to calculate such an EU total different options for extrapolating the received data were explored. The graphics below visualize the plots of reported costs for the MSFD initial assessment against coastline length and the size of the Exclusive Economic Zone (EEZ) of the respective Member States[23]. Neither the coastline length nor the size of the EEZ showed strong correlation with reported costs and these two factors were hence not used for the extrapolation of costs.

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[23] Data on coastline length: The World Factbook and data on EEZ from the Seas Around Us Project.

Figure 3-1 Scatter plot reported costs / coastline length

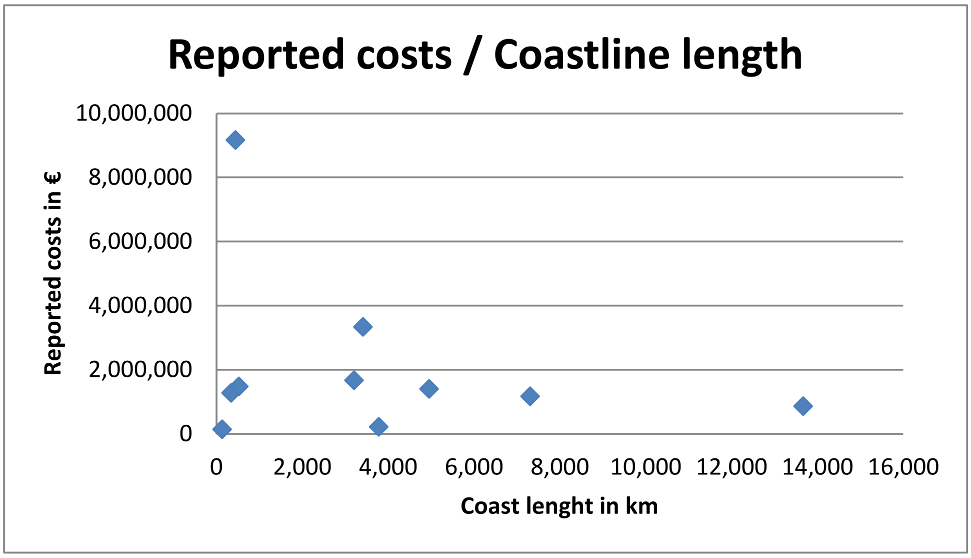
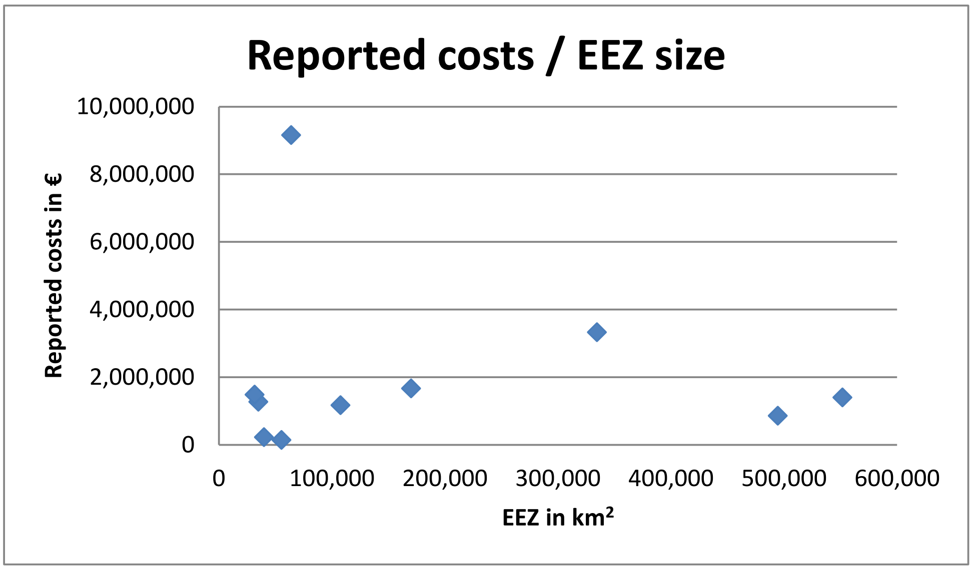


Figure 3-2 Scatter plot reported costs / EEZ size



Due to the low level of correlation of costs with either coastline length or EEZ size this study will treat countries equally independent of the physical properties and only take account of GDP/labour cost differences. The table below presents the reported as well as the extrapolated implementation costs.

Table 3-3 Extrapolated MSFD implementation costs

Countries	Reported MSFD implementation costs up to now	GDP adjusted implementation costs to now	Labour cost adjusted implementation costs to now
1	700.000 €	853.659 €	889.474 €
2	1.460.000 €	1.168.000 €	878.078 €
3	1.385.000 €	1.398.990 €	1.648.345 €
4	145.000 €	216.418 €	480.490 €
5	571.574 €	1.270.164 €	4.829.800 €
6	960.000 €	1.476.923 €	2.351.304 €
7	2.095.000 €	1.662.698 €	1.469.108 €
8	112.400 €	135.422 €	204.254 €
9	12.000.000 €	9.160.305 €	9.703.349 €
10	3.560.000 €	3.327.103 €	2.759.817 €
Sum of reported MSFD implementation costs		20.669.682 €	25.214.019 €
Extrapolated MSFD implementation costs for all 22 countries		**45.000.000 €**	**55.000.000 €**

Source: Member State Questionnaire replies

On the basis of the reported MSFD implementation costs until now from 10 Member States and an adjustment based on GDP levels or labour costs levels, the estimated costs for all 22 relevant countries lie between EUR 45 million and 55 million. These values are obtained by calculating the average costs per country from those 10 Member States that reported costs and multiplying it by 22. Since the averages are based on the average GDP level and the average labour cost level in the EU, the extrapolated costs can be seen as good rough estimate of the actual costs that have occurred in relation to the MSFD initial assessment.

The data costs of the initial assessment were also related to the specific Article 8 activity. This distribution of costs was obtained from three Member States and the results are presented in Table 3-4.

Table 3-4 Distribution of the MSFD implementation costs by Article 8 activity

	Share of costs in %		
Article 8 tasks	**MS1**	**MS2**	**MS3**
Gather data / information	75	15	78
Process and manage data (e.g. prepare data products for assessment)	8	40	
Assessment (data interpretation)	12	15	
Prepare report (paper) - content	2	15	
Prepare electronic report (reporting sheets or equivalent format) - content	1	0	

	Share of costs in %		
Article 8 tasks	**MS1**	**MS2**	**MS3**
Public consultation and response (finalise report contents)	0	5	
Transfer information (e.g. from reporting sheets or paper reports) to MSFD database (if used) or equivalent national data	2	8	20
Prepare XML schemas (export from MSFD database or national system) and upload to ReportNet	0	1	
Complete validation checks (with Atkins) on XML schemas	0	1	2
Total	100	100	100

Source: Member State Questionnaire replies

3.3.2 Effort until 2020 (Question 6)

Question 6 inquires into the efforts to be undertaken by Member States until 2020 on data acquisition, management and dissemination in meeting the requirements of the Marine Strategy Framework Directive.

For the purpose of this study and in order to obtain comparable estimates from Member States the total effort to be borne by Member States in meeting the MSFD requirements was assumed to consist of existing monitoring programmes, new monitoring/surveying programmes and other new activities. The table below provides estimates for the total cost of existing and new activities under the MSFD between 2013 and 2020 for three Member States.

Table 3-5 Reported costs for existing and new activities 2013-2020

Annual costs of new monitoring/surveying programmes	Total costs of new monitoring/surveying: Man power costs	Annual costs of existing monitoring programmes	**Total cost for existing and new activities 2013-2020 (estimates)**	**GDP adjusted costs of existing and new activities 2013-2020**
800.000 €	200.000 €	400.000 €	**11.200.000 €**	**13.658.537 €**
At present 800.000/year allocated (Sum allocated may be subject to changes. Marine survey programmes are at present expected to continue feeding in to multiple purposes)	Not known at present (Cannot be estimated as a total reorganisation of the national marine monitoring programme is required. There will also most likely be a coordination with other monitoring programmes (fisheries, joint with other member states etc))	8.000.000/year (this sum includes the man power costs)	**70.400.000 €**	**56.320.000 €**
150.000€ (2013 only. Yearly costs can be increased by approx. 10% per year)	100.000 €	425.000€ (including WFD monitoring, except ichtiological monitoring)	**5.915.383 €**	**9.100.589 €**

Source: Member State Questionnaire replies

The estimated annual costs between the three Member States differ greatly. This is however likely to be due to different standards regarding the reporting of monitoring programmes as well as the differing size of their marine waters. In the second country the new and most likely also existing monitoring programmes feed into multiple purposes and the annual costs related only to the MSFD are hence likely to be much lower. In order to make the replies more comparable they have been adjusted using the GDP levels of the respective three countries.

3.3.3 Cost of assembling existing data (Question 7)

Question 7 aims at establishing an overview of the costs of assembling existing data. As marine data need to be collected constantly, the term existing data in this context hence refers to existing monitoring programmes that deliver the status of existing data. The table below illustrates the total annual costs as well as the total costs for the period 2013 to 2020 for existing monitoring programmes in nine Member States. In relation to the reported costs it should be mentioned that the monitoring programmes that the Member States maintain typically not only provide data to the MSFD but also to other purposes. Furthermore data from other monitoring programmes can be used for MSFD reporting. The field of marine fisheries e.g. is one that is closely monitored and where there is a strong overlap between reporting for the MSFD and the EU common fisheries policy. The provided costs of existing monitoring programmes should hence be seen in light of this difficulty to separate monitoring costs of programmes feeding into multiple purposes.

Table 3-6 Reported costs of existing monitoring programmes

	Annual man power costs	Annual costs of monitoring equipment	Other annual costs	Total annual costs of existing monitoring programmes	**Total cost 2013-2020**
1	100.000 €	250.000 €	50.000 €	400.000 €	**3.200.000 €**
2				8.000.000 €	**64.000.000 €**
3	700.000 €	1.500.000 €		2.200.000 €	**17.600.000 €**
4				2.200.000 €	**7.200.000 €**
5	189.178 €	57. 265 €	246.954 €	436.132 €	**3.489.056 €**
6	215.000 €	130.000 €	80.000 €	425.000 €	**3.400.000 €**
7				4.400.000 € (2012)	**35.200.000 €**
8				3.000.000 €	**24.000.000 €**
9	18.900 €	30.840 €	5.000 €	54.740 €	**437.920 €**

Source: Member State Questionnaire replies

Two of the Member States reported very high yearly costs of existing monitoring programmes (EUR 8,000,000 and EUR 4,400,000 respectively). This is likely to be due to these monitoring programmes not only providing data for the Marine Strategy Framework Directive, but also feeding into other purposes. MSFD-related monitoring costs can hence be expected to be lower. Two countries reported figures for the cost of implementation of Articles 8, 9 and 10, i.e. the initial assessment of the state, formulation of criteria for good environmental status (GES) and of environmental targets for the marine environment. Both countries have access to one sea and a relatively small Exclusive Environmental Zone (EEZ) and reported costs of EUR 145,000 and EUR 135,442 respectively.

In order to explore whether an extrapolation of the reported costs is possible using either coastline length or EEZ size plots for both variables were prepared as shown below. However, also in the case of costs for assembling existing data, there seems to be no correlation with the physical properties of countries and their seas. The study will hence use GDP levels and labour cost levels for approximating costs for all 22 coastal states.

Figure 3-3 Scatter plot reported costs / coastline length

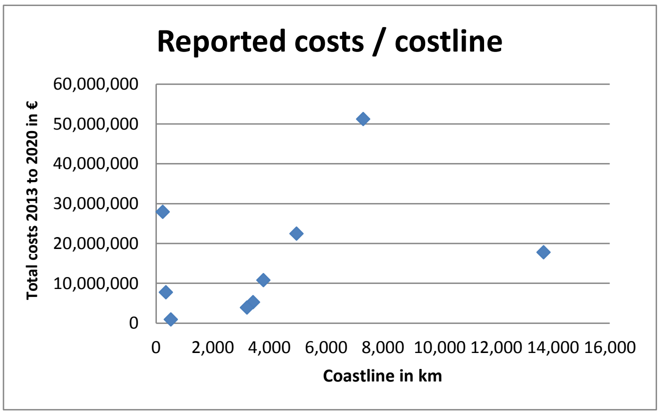
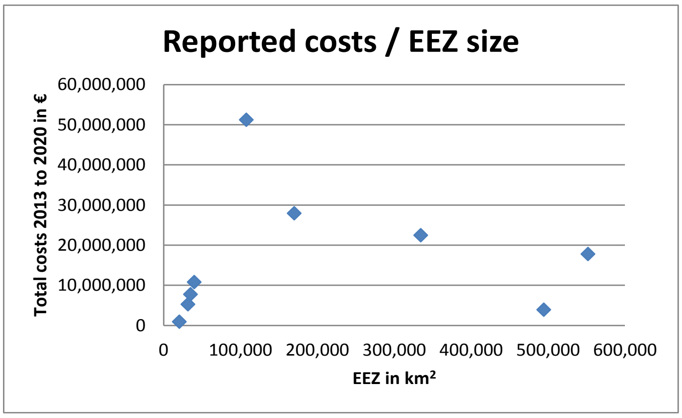


Figure 3-4 Scatter plot reported costs / EEZ size



The table below presents the GDP and labour cost adjusted costs of existing monitoring programmes in the nine Member States that reported costs and a calculation of extrapolated costs for all 22 coastal states.

Table 3-7 Extrapolated costs of existing monitoring

	Total cost 2013-2020	GDP adjusted costs	Labour cost adjusted costs
1	3.200.000 €	3.902.439 €	4.066.165 €
2	64.000.000 €	51.200.000 €	38.491.103 €
3	17.600.000 €	17.777.778 €	20.946.479 €
4	7.200.000 €	10.746.269 €	23.858.824 €
5	3.489.056 €	7.753.458 €	29.482.523 €
6	3.400.000 €	5.230.769 €	8.327.536 €
7	35.200.000 €	27.936.508 €	24.683.817 €
8	24.000.000 €	22.429.907 €	18.605.505 €
9	437.920 €	893.714 €	2.387.370 €
Yearly costs of existing monitoring in 9 MS		18.483.855 €	21.356.165 €
Extrapolated costs of existing monitoring in all 22 countries		**45.182.757 €**	**52.203.960 €**

Source: Member State Questionnaire replies

3.3.4 Cost of collecting new data (Question 8)

A second part of the total effort to be borne by Member States for the implementation of the MSFD are new monitoring/surveying programmes that will provide marine data to meet reporting requirements.

The table below presents the estimates provided by four Member States for annual costs of new monitoring/surveying programmes to meet the requirements of the Marine Strategy Framework Directive. The totals costs for the period 2013-2020 have been calculated on the basis of a multiplication of the reported costs by 8. However, this should only be seen as a rough approximation of the actual costs.

Table 3-8 Reported costs of new monitoring programmes

Annual man power costs	Annual costs for monitoring equipment	Other annual costs	Total annual costs of new monitoring/surveying programmes	**Sum monitoring/surveying costs 2013-2020**
200.000 €	550.000 €	50.000 €	800.000 €	**6.400.000 €**
Not known at present (Cannot be estimated as a total reorganisation of the national marine monitoring programme is required. There will also most likely be a coordination with other monitoring programmes (fisheries, joint with other member states etc))			At present 800.000€ /year allocated (Sum allocated may be subject to changes. Marine survey programmes are at present expected to continue feeding in to multiple purposes)	**6.400.000 €**
100.000 €		50.000 €	150.000€ (2013 only. Yearly costs can be increased by approx. 10% per year)	**1.715.383 €**
			2.450.000€ (costs for the year 2013/2014)	**10.000.000 €**

Source: Member State Questionnaire replies

Two countries reported yearly costs of EUR 800,000 for new monitoring/surveying programmes while a third country reported EUR 150,000 for 2013 with a yearly increase of approximately 10% thereafter and country four reported yearly costs of EUR 2,500,000.

To increase comparability of the reported costs, they have been adjusted using GDP levels in the respective countries. An extrapolation of the costs for the four Member States gives an estimate of yearly costs of EUR 21 million for all 22 coastal states. This is, however, a very rough estimate, which should only be considered indicative as it is based on data from four Member States only.

Table 3-9 Extrapolated costs of new monitoring programmes

	Total annual costs of new monitoring/surveying programmes	**Sum monitoring/surveying costs 2013-2020**	**GDP adjusted costs**
1	800.000 €	6.400.000 €	7.804.878 €
2	At present 800.000€ /year allocated (Sum allocated may be subject to changes. Marine survey programmes are at present expected to continue feeding in to multiple purposes)	6.400.000 €	5.120.000 €
3	150.000€ (2013 only. Yearly costs can be increased by approx. 10% per year)	1.715.383 €	2.639.051 €
4	2.450.000€ (costs for the year 2013/2014)	10.000.000 €	15.384.615 €
Total costs for 4 Member States 2013-2020			**30.948.544 €**
Extrapolated yearly costs of new monitoring/surveying in 22 coastal states			**21.277.124 €**

Source: Member State Questionnaire replies

While not many replies were received regarding the costs of new monitoring programmes, twelve Member States provided a ranking of expected costs for additional monitoring/surveying programmes in areas with current data gaps. The table below presents a summary of the ranking of costs obtained from ten countries. Respondents were asked to rank data areas by expected costs in the future, with a 1 indicating highest costs and 5 indicating lowest costs (the same rank could be given to several areas). The list below is sorted by expected costs, from highest to lowest.

Table 3-10 Average ranking of expected future costs

Average ranking of expected future costs	
Physical features (8A01)	1,4
Habitats (8A02)	1,9
Functional groups (8A03)	1,9
Ecosystems (8A05)	2,3
Species (8A04)	2,4
Contamination by hazardous substances (8B06)	2,6
Nutrients and organic matter enrichment (8B08)	2,7
Underwater noise (8B03)	2,7
Microbial pathogens (8B09)	3,0
Marine litter (8B04)	3,1
Non-indigenous species (8B10)	3,2

Average ranking of expected future costs	
Extraction of species (fish, shellfish) (8B11)	3,3
Other features (8A07)	3,5
Interference with hydrological processes (8B05)	3,6
Acute pollution events (8B07)	3,7
Non-indigenous species inventory (8A06)	3,7
Physical loss (8B01)	3,7
Marine acidification (8B12)	3,8
Use of marine waters: ecosystem services and other approaches (8C02)	3,9
Cost of degradation (8C03)	4,1
Use of marine waters: human activities and marine water accounts approach (8C01)	4,2
Physical damage (8B02)	4,5
Extraction of species (seaweed, maerl, other) (8B11)	5,0

Source: Member State Questionnaire replies

3.3.5 Data gaps

In relation to the MSFD data collection that Member States are planning up to 2020 and its expected costs, COWI's questionnaire also inquired into the areas in which most data gaps exist. The table below shows the replies of 13 countries to the question whether no, few, some or many gaps exist in the following data categories.

Table 3-11 Reported data gaps

Number of countries that reported	No gaps	Few gaps	Some gaps	Many gaps
Underwater noise	0	0	0	13
Marine litter	0	0	3	9
Habitats	0	0	2	9
Cost of degradation	0	1	2	8
Ecosystems	0	1	3	7
Use of marine waters: ecosystem services and other approaches	0	1	3	7
Species	0	3	1	7
Functional groups	0	2	3	6
Marine acidification	1	1	2	6
Non-indigenous species	2	2	3	5
Physical loss	2	1	3	5
Interference with hydrological processes	2	1	3	5
Non-indigenous species inventory	0	4	2	5
Physical damage	1	2	4	4
Contamination by hazardous substances	1	6	2	4
Use of marine waters: human activities and marine water accounts	1	1	6	3
Microbial pathogens	2	3	2	3
Extraction of species (seaweed, maerl, others)	2	1	2	3
Extraction of species (fish, shellfish)	2	2	5	2
Physical features	2	4	4	2
Other features	0	1	5	1
Acute pollution events	1	7	2	1
Nutrients and organic matter enrichment	1	6	5	0

Source: Member State Questionnaire replies

3.4 Overview/summary

The estimation of the cost of data for the MSFD has been limited by the number of Member States that replied to the questionnaire. Furthermore the Member States' estimates are difficult to compare as it is not always clear which costs are included and which are not. However, the 10 Member States that provided information represent a good sample of all EU coastal states (location, population, GDP level, coastline, geography).

In order to provide answers to questions 6, 7 and 8 of the Terms of Reference the estimates from the respondent countries needed to be scaled up. As described above, the reported costs, however, only showed no or only weak correlation with coastline lengths and the size of the EEZs. The reported costs have therefore been adjusted using GDP levels and labour costs and scaled up for 22 coastal states using average costs. Due to the diverse geography, economic and social properties of the respondent countries this method provided the best results. The estimates that have been calculated in response to the questions in the Terms of Reference for this project are the following:

- Estimates of the efforts related to the initial assessment in the 22 coastal Member States and Croatia: EUR 45-55 million.

- Estimate of yearly cost of assembling data from existing monitoring programmes: EUR 45-52 million.

- Estimate of yearly costs for new monitoring programmes: around EUR 20 million as an order of magnitude estimate.

- The estimate of the effort related to the initial assessment is the least uncertain of the estimates. Regarding existing monitoring programmes that provide data to the MSFD, Member States might have included mainly the environmental programmes. Data are typically also provided from other monitoring activities for example monitoring of fisheries. Hence, the costs of existing programmes that provides data for the MSFD are likely to be underestimated.

- The estimate of the costs of new monitoring programmes is also likely to be an underestimate as only very few Member States were able to provide input on new programmes. In many cases the decisions on new monitoring programmes have not yet been made and hence, it has proven difficult for Member States to provide estimates that could support the assessment.

4 Cost of data for offshore wind farms

4.1 Introduction

4.1.1 Background

By 2012, a total of 55 offshore wind farms with a total capacity of about 5 GW had been built in ten European countries (Table 4-1).

Table 4-1 Offshore wind installations in Europe established by 2012 (Source: EWEA (2013) The European offshore wind industry-key trends and statistics 2012. January 2013)

Country	No of farms established	Number of turbines installed	Capacity installed (MW)
United Kingdom	20	870	2,947.9
Denmark	12	416	921
Belgium	2	91	379.5
Germany	6	68	280.3
Netherlands	4	124	246.8
Sweden	6	75	163.7
Finland	2	9	26.3
Ireland	1	7	25.2
Norway	1	1	2.3
Portugal	1	1	2.0
Total	55	1,662	4,995

The Member States projected an installed offshore wind farms capacity of 43GW for the year 2020 in their National Renewable Energy Action Plans. The European

Wind Energy Association (EWEA) expects an installed capacity of about 40 GW for the same year. Regardless of which projection will show to be more precise, Europe will see major growth in offshore wind capacity. A large share of this growth will come from Member States that currently have no or only very few operational wind farms.

Operators will need to collect or purchase marine data and further assemble and process it for preparing licence applications and for planning, building and operating wind farms. With many projects being planned in new areas, this will result in considerable costs, as data might not be existent or difficult to access.

4.1.2 Objective of task

The aim of this task is to collect information on the costs related to data collection and usage for offshore wind farms in the EU coastal countries plus Croatia, Norway and Iceland until 2020. The objectives of this task are to be able to answer questions 9 and 10 of the Terms of Reference:

- What marine data will be required for planning, building and operating offshore wind farms in Europe up to 2020?
- How much will be spent collecting, purchasing, assembling and processing these data?

4.2 Method

4.2.1 Outline of component

The study on this component has been carried out as follows:

- Initially, information of the types of marine data that are needed for planning, building and operating offshore wind farms in different European countries has been collected.
- The information on data needs has then served as a basis for the estimation of costs for collection, purchase, assembly and processing of this data for a 200 MW wind farm in different European countries.
- Information estimates on the offshore wind capacity to be planned, built or operational in Europe by 2020 has been collected.
- Estimations on data needs, capacity growth and data costs have been used to project the total costs related to marine data of the growth in offshore wind farms until 2020.

Two methodologies were used to collect information on data needs and data costs:

- Submission of questionnaires to European wind farm operators on data needs and typical costs for a 200 MW offshore wind farm

- Own assessments based on review of EIAs, monitoring reports and guidelines and knowledge of costs of different types of investigations.

4.2.2 Questionnaire

A questionnaire on data needs and costs of data for planning building and operating offshore wind farms was prepared in cooperation with EWEA in Brussels. EWEA submitted the questionnaire to their members (wind farm operators in Europe).

We received filled questionnaires from six operators of which only three had been filled with all the requested information on data costs (two from Germany and one from UK). The remaining three include data needs but only costs for meteorological data.

4.2.3 Own assessment of data need and costs

In the light of the somewhat meagre result from the questionnaires, we carried out an alternative approach to supplement the information from the questionnaires. We have carried out our own assessments based on review of EIAs, monitoring reports and guidelines from different member states and knowledge on costs of different types of investigations. The assessment has included:

- Detailed review of existing EIAs, monitoring reports and guidelines on offshore wind farms from different member states in order to:

  - Get information on marine data usually required for planning, building and operating offshore wind farms in Europe

  - Get detailed information on types of investigations, methodology and scope of investigations required in the different Member States (such as number of samples of different, number of sampling sites etc.).

- Estimation of typical costs of different investigations in different countries based on this and our own knowledge of expenditure of time and typical costs of different types of investigations and knowledge on differences in salaries and costs in different countries.

The results of the review and estimates of costs of data for EIA and monitoring are presented in Appendix B.

4.2.4 Countries covered

We have collected information on requirements and costs for the following countries:

- United Kingdom

- Denmark
- Belgium
- Germany
- Netherlands
- Sweden.

These countries represent 99% of the offshore wind farm capacity installed by 2012 (cf. Table 4-1).

4.3 Data requirements

4.3.1 Project phases

Establishment of an offshore wind farm usually includes the following project phases:

- Planning phase, which includes:
  - Site screening, the purpose of which is to identify sites where locations for offshore wind farms would be feasible and have the least possible environmental impact on nature and humans
  - Conceptual design, which aims at selecting the best suited technical foundation solution for each wind farm location and characteristics. The basis for the economic assessment of an offshore wind farm is established in terms of construction costs and operation and maintenance costs
  - Feasibility study aiming at assessing the economical feasibility of the project
  - Environmental Impact Assessment (EIA) of the wind farm
- Construction phase, which also includes monitoring of environmental impacts
- Operation phase, which also includes monitoring of environmental impacts
- Decommissioning phase.

4.3.2 Data requirement planning

Data needed for site screening, conceptual design and feasibility study

Wind studies are required in order to make reliable assessment of the economic viability of planned wind farms. Such wind studies can normally only be made using wind data measured at the actual sites.

Wind data can be measured by met masts on which a number of sensors for measuring meteorological parameters are installed. Another method is using a Lidar system where the wind speed is measured by laser interference technology.

Wind data are typically measured for a period of *minimum one year*. Measurements for at least one year are necessary to cover the annual wind speed variation. The wind measurements are made at *several heights* above ground level in order to determine the vertical wind speed gradient. The minimum measuring height is the hub height of the wind turbine planned for the project. The hub height of future off shore wind turbines will be in the order of 120-140m. The *number of wind measurement* positions required depends on the size of the wind farm area, the complexity of the surface and the wind speed gradient across the area.

Detailed information on bathymetry, geophysical/geotechnical conditions at the potential wind farm sites are required for the site selection and conceptual design in order to:

- Provide sufficient geological knowledge of the area to be able to select the best location and the most cost efficient foundation design.
- Provide safety to the project in terms of knowledge of potential hazardous objects on the seabed and subsurface which might represent a risk for following stages of the project.

The following site-specific surveys are usually carried out:

- Survey using Single Beam Echosounder (SBES) or Multibeam Echosounder in order to measure the water depths
- Survey using Side Scan Sonar (SSS) in order to generate an acoustic image of the seabed
- Survey using magnetometer in order to detect ferromagnetic material in the subsurface. A special case of a magnetometer survey is an Unexploded Ordnance survey (UXO) in order to assess if there is a risk of presence of unexploded ordnance
- Survey by Reflection Seismics in order to study the vertical layering of the seabed
- Geotechnical site investigations which includes boreholes, CPTs and laboratory testing

Baseline data needed for the EIA

In order to obtain permission to establish an offshore wind farm, the operator must carry out an assessment of the environmental consequences of the project and prepare an Environmental Impact Assessment (EIA) report that has to be approved by the authorities. Marine data needed for the preparation of the EIA are outlined in **Error! Not a valid bookmark self-reference.**, Table 4-3 and Table 4-4 below.

Table 4-2 Metocean data, bathymetrical data and geophysical data needed for the preparation of the EIA and methodology for obtaining data

Data needed for the preparation of the EIA	Methodology applied for obtaining data
Metocean data	
The following Metocean data are needed for the preparation of the EIA: › Wind direction and force › Atmospheric pressure and Air temperature › Water level, › Salinity › Water temperature › Water quality › Currents (direction and velocity) › Wave height › Wave amplitude and Wave direction	Existing metocean data are normally used for scoping of the EIA. Data from site specific metocean will also be used for the EIA if such a survey is carried out. Metocean data are mainly used for hydrological modelling.
Bathymetrical and geophysical data	
The following bathymetrical and geophysical data are needed for the preparation of the EIA: › Bathymetry data › Sediment data › Composition of sediments (geochemical properties, grain size distribution, organic content loss on ignition) › Contaminants in sediment (nutrients, heavy metals, other hazardous substances)	Existing data are normally used for scoping of the EIA. Data from the detailed geophysical/geotechnical survey carried out for assessing the suitability of the seabed for wind farm foundations are usually used for preparing the EIA.

Table 4-3 Data on benthic fauna and vegetation and fish and shellfish needed for the preparation of the EIA and methodology for obtaining data

Data needed for the preparation of the EIA	**Methodology applied for obtaining data**
Benthic fauna and vegetation	
The following benthic fauna data are needed for the preparation of the EIA: › Abundance of different species of infauna › Coverage/abundance of different species of epifauna and vegetation › Extension of different benthic fauna associations	Existing benthic fauna and vegetation data are normally used for scoping of the EIA. The following field investigations are usually carried out for obtaining site specific baseline data on benthic fauna and vegetation for the EIA: › Quantitative sampling of benthic infauna and sediment by grab or core sampler. In the laboratory the fauna is sorted, animals identified and enumerated. Particle size and organic matter content of sediment are determined. Patterns and trends in the data are analysed using uni- and multivariate statistical analyses in order to identify benthic fauna associations. › Videosurvey and photosampling of extent and coverage of epifauna and benthic vegetation by SCUBA diver along transects. Drop down video-survey are also sometimes conducted. › Sampling of epibenthic species by trawling or by dredge. The samples are sorted and animals are identified and enumerated. Patterns and trends in the data are analysed using uni- and multivariate statistical analyses. › Sampling of epibenthic fauna by dredge. The samples are sorted and animals are identified and enumerated. Data are subject to multivariate statistic analysis. Patterns and trends in the data are analysed using uni- and multivariate statistical analyses. › Maps of the extent of different benthic fauna and flora associations are usually produced based on data collected during these investigations
Fish and shellfish	
The following fish data are needed for the preparation of the EIA: › Species composition and abundance of different species in the project area › Location of spawning grounds, nursery grounds, feeding grounds and overwintering areas for different species of fish and shellfish › Migration routes for fish	Information on location of spawning grounds, nursery grounds, feeding grounds overwintering areas and migration routes has for the EIAs reviewed all been based on compilation and of existing data. The species composition and abundance of fish and shellfish species are usually investigated by the following methods: › Test trawling along transects using otter trawl or beam trawl in order to sample demersal fish and shellfish species. Fish and shellfish are identified to species and counted (length, weight, sex, maturity and otholits may be determined as well). Catch per unit effort for each species for numbers and biomass are determined and the data subject to statistical analysis › Pelagic trawl sampling of pelagic fish species. Catch per unit effort for each species for numbers and biomass are determined and the data subject to statistical analysis › Hydro-acoustic survey of pelagic fish and trawling for validation › Test fishing using gill nets or fyke nets. Catch per unit effort for each species for numbers and biomass are determined and the data subject to statistical analysis

Table 4-4 Data on birds, marine mammals and human use needed for the preparation of the EIA and methodology for obtaining data

Data needed for the preparation of the EIA	Methodology applied for obtaining data
Birds	
The following data on birds are needed for the preparation of the EIA: › Overall distribution, density and population size of birds in the project area › Migration routes and movements in/around or through the project area › Relative importance of the project area to each species	Existing bird data are normally used for scoping of the EIA. The following field investigations are usually carried out for obtaining site specific baseline data on birds for the EIA: › Aerial surveys of the distribution, density and population size of birds › Ship based surveys of the distribution, density and population size of birds › Radar and visual observations of bird migration
Marine mammals	
The following data on marine mammals are needed for the preparation of the EIA: › Overall distribution, density and population size of cetaceans and seals in the project area › Migration routes and movements by cetaceans and seals in/around or through the project area › Relative importance of the project area to each species	Existing data on marine mammals are normally used for scoping of the EIA. The following field investigations are usually carried out for obtaining site specific baseline data on marine mammals for the EIA: › Aerial surveys of the distribution, density and population size of seals and cetaceans (mainly harbour porpoise) › Ship based surveys of the distribution, density and population size of seals and cetaceans (mainly harbour porpoise) › Acoustic monitoring of cetaceans using so-called T-PODs that detects and logs echolocation clicks from harbour porpoises and other cetaceans. › Tagging with satellite transmitters and satellite monitoring of seals
Human use data	
Data on the following human use issues are usually needed: › Commercial fisheries › Shipping and navigation › Aviation and military operations › Telecommunications and interference › Archaeology and cultural heritage › Landscape, seascape and visual › Infrastructure and other users/activity › Air quality › Airborne noise	Usually existing data are used. Site specific field surveys on archaeology may be carried out. However, the scope of such an investigation varies considerably between sites and coasts are difficult to estimate.

4.3.3 Data requirement during construction and operation

Wind data are routinely collected during operation

Geotechnical surveys are often carried out after construction in order to assess whether the wind farm affects seabed conditions (such as generation of scour holes).

Following the approval of the EIA for a wind farm, the Authorities stipulate in the environmental permits that a monitoring programme is carried out to monitor the positive and negative effects of the windmill. The monitoring programmes stipulated for European wind farms so far have included:

› Monitoring of impacts on and recovery of impacted habitats and organisms arising from construction activities (especially excavation and dredging operations during the installation of foundations and cable laying (mainly impacts on benthic fauna and vegetation and fish)

› Monitoring of impacts on marine organisms and habitats due to altered current patterns and sediment transport resulting from the presence of turbines.

› Monitoring of behaviour of marine mammals – porpoises and seals – and their reaction to presence of wind farms (for instance reaction to underwater noise from piling during the construction phase and from the turbines noise during the operation phase)

› Monitoring of noise and disturbances on birds during construction

› Monitoring of colonisation of epifauna, vegetation and associated fish fauna on turbine piles, foundations or scour protection

› Monitoring of risk of collisions between birds and wind turbines

› Monitoring of barrier effect and displacement effects on birds due to the presence of the wind turbines

› Monitoring of impacts on fish migration due to electromagnetic fields around the power cables.

The monitoring data and the methodology that have been applied to obtain these data are shown in Table 4-5 and Table 4-6.

Table 4-5 Monitoring data for benthic fauna and vegetation and fish and shellfish and methodology applied for monitoring

<table>
<tr><th>Impacts and recovery of impacted organisms that are monitoring during the construction and operation phase of the Wind farm</th><th>Methodology applied for monitoring</th></tr>
<tr><td colspan="2">Benthic fauna and vegetation</td></tr>
<tr><td>The following impacts on benthic fauna resulting from construction and presence of windturbines and cable are usually monitored:
› Impacts on and recovery of soft bottom benthic fauna
› Impacts on and recovery of benthic epifauna and vegetation
› Colonisation of epifauna and vegetation on piles, foundations and scour protection</td><td>The following methods have been applied for monitoring impacts on benthic fauna and vegetation from wind farms:
› Monitoring of impacts on and recovery of soft bottom benthic infauna by quantitative sampling using grab or core sampler.
› Monitoring of impacts on and recovery of epifauna and benthic vegetation by videosurvey, photosampling and quantitative sampling by diver or by the use of trawl or dredge
› Monitoring of colonisation of organisms on monopiles, foundations and scour protection layers by videosurvey, photosampling , visual observation and quantitative sampling of epifauna and benthic vegetation by SCUBA diver Sampling of epibenthic species by trawling or by dredge.</td></tr>
<tr><td colspan="2">Fish and shellfish</td></tr>
<tr><td>The following impacts on fish and shellfish resulting from construction and presence of windturbines and cable are usually monitored:
› Impacts on the composition of fish fauna in the area
› Attraction of reef/hard bottom associated fish fauna at piles, foundations and scour protection.
› Monitoring of impacts on fish migration due to electromagnetic fields around the power cables.</td><td>The following methods have been applied for monitoring impacts on fish and shellfish from wind farms:
› Monitoring of pelagic fish by hydro-acoustic survey and trawling for validation
› Monitoring of demersal fish and shellfish by trawling with otter trawl or beam trawl sampling
› Monitoring of attraction of fish at turbine piles, foundations and scour protection by underwater census of fish by SCUBA divers, static hydroacoustic survey, line fishing, gill nets fishing
› Tagging and telemetry experiments to monitor the potential effects of wind farms on fish migration and behaviour
› Monitoring of changes of fish diet at wind farm by stomach analyses of fish caught at the wind farm
› Test fishing with fyke nets deployed on both sides of the cable from the wind farm in order to assess any impacts on fish migration from electromagnetic fields around the cable.</td></tr>
</table>

Table 4-6 Monitoring data for birds and marine mammals and methodology applied for monitoring

Impacts and recovery of impacted organisms that are monitoring during the construction and operation phase of the Wind farm	**Methodology applied for monitoring**
Birds	
The following impacts on birds resulting from construction and presence of windturbines and cable are usually monitored: › Risk of collisions between birds and wind turbines › Barrier effect and displacement effects on birds due to the presence of the wind turbines	The following methods are usually applied for monitoring impacts on birds from wind farms: › ›Ship based counts of bird numbers and distribution › Aerial surveys of bird numbers and distribution › Monitoring of flight paths of birds flying through the wind farm by radar and/or visual observation. Acoustic observations of migrating birds has also been carried out in a few cases.
Marine mammals	
The following impacts on mariner mammals resulting from construction and presence of windturbines and cable are usually monitored: › Behaviour of marine mammals – porpoises and seals – and their reaction to presence of wind farms (for instance reaction to underwater noise from piling during the construction phase and from the turbines noise during the operation phase)	The following methods have been applied for monitoring impacts from wind farms on marine mammals: › Aerial monitoring of the distribution, density and population size of seals and cetaceans (mainly harbour porpoise) › Ship based monitoring of the distribution, density and population size of seals and cetaceans (mainly harbour porpoise) › Acoustic monitoring of cetaceans using so-called T-PODs that detects and logs echolocation clicks from harbour porpoises and other cetaceans. › Monitoring of seals by tagging with satellite transmitters › Monitoring of acoustic underwater noise before, during and after construction

4.4 Costs of data for one offshore wind farms

4.4.1 Physical data

Met-ocean data[24]

[24] The estimates of the costs of wind data, oceanographic data, bathymetrical/geophysical and geotechnical data presented in this section are based expert assessment from COWI's marine foundation experts.

Wind data

An offshore wind measurement station consists of a foundation for the measuring equipment and the measuring equipment itself. In general, the foundation concepts for offshore wind measuring equipment are similar to the foundation concepts for wind turbines. The type of foundation depends on the water depth at the position where the measurement station is to be installed. At water depths up to 10 m, a monopole foundation concept is suitable. At water depths above 10 m a jacket foundation concept is more suitable.

The construction costs for offshore wind measuring stations can be divided into two parts: costs for the foundation and costs for the measuring equipment.

The major cost of offshore wind measuring stations is the foundation cost, which depends on the water depth. For water depths in the range between 6-10 m the costs will be in the order of EUR 1.3 million. At water depths above 10 m and up to approximately 40 m, the foundation costs are in the order of EUR 2.6 million. The relatively high costs for the foundations are mainly due to the sea operation costs.

The measurement equipment costs (met masts or Lidar) are in the order of EUR 0.26 million.

The operation activities include regular collection and analysis of data. This activity will require say a man day per week corresponding to DKK 0.3 mill per year.

The maintenance activities include planned maintenance and ad hoc maintenance. The planned maintenance will typically include visits to the masts for cleaning/check of power supply system. Ad hoc maintenance includes repair of equipment, e.g. sensors. The maintenance costs can roughly be estimated to be at the same level as the operation costs.

The costs of one offshore wind measurement station are:

Construction	EUR 1.6 million (water depths 6 - 10m) EUR 2.9 million (water depths 10-40m)
Operation and maintenance	EUR 0.07 million/year

Oceanographic data

The costs of oceanographic data are highly variable ranging in the planning phase between EUR 55,000 and EUR 2,540,000. The significant difference is probably due to differences in the volume of field surveys that has been carried out.

Bathymetrical/geophysical and geotechnical data

The costs of bathymetrical/geophysical and geotechnical data are typically around EUR 1,800,000 for the planning phase and EUR 12,900,000 for the construction phase, the bulk of the costs are costs for geotechnical site surveys. The costs may be significantly higher than the typical costs. There are examples of sites in

Germany with bad soil conditions where the costs were in the range of EUR 15,000,000 to 25,000,000.

Costs of physical data from operator survey

Table 4-7 shows the estimated costs of physical data for an offshore wind farm of around 200 MW.

Table 4-7 Estimated costs of collecting, purchasing, assembling and processing marine physical data needed for planning, building and operating a wind farm of 200 MW in different European countries in € per wind farm

Data needed	Denmark	Germany 1	Germany 2	UK	Mean
Planning Phase					
Meteorological data 1) Existing data	15,000	-		-	
Meteorological data 2) Site-specific measurements shallow water 6-10 m	1,700,000	-		-	
Meteorological data 3) Site-specific measurements deeper waters 10-40 m	3,140,000	-		-	
Oceanography data	105,000	-		-	
Total metocean data	2,540,000*	55,000	65,000	300,000	740,000
Bathymetrical/geophysical data/geotechnical	2,000,000	1,600,000	250,000	700,000	1,800,000**
Construction phase					
Metocean data	-	3,000	115,000	55,000	43,000
Bathymetrical/geophysical/geotechnical data	13,000,000	12,800,000	100,000	400,000	12,900,000**
Operation phase					
Met-ocean	-	200,000	65,000		66,000
Bathymetry/geophysics	-	80,000	500,000		145,000

* In this sum the mean of meteorological data 2 and 3 has been used
** Only mean of Denmark and Germany 1, Because Germany 2 and UK has not included geotechnical site investigations

4.4.2 Biological data

Estimated costs of biological data for a wind farm of around 200 MW for different countries are shown in Table 4-8.

Table 4-8 Estimated cost of collecting, purchasing, assembling and processing marine biologicaldata needed for planning, building and operating a wind farm of 200 MW in different European countries.

Data needed	Denmark 1 €	Denmark 2 €	Germany 1 €	Germany 2 €	UK 1 €	UK 2 €	UK 3 €	Belgium €	Netherlands €	Sweden €	Mean €
Planning phase											
Benthic flora and fauna	190,000	190,000	1,200,000	425,000	260,000	80,000	90,000	No data	200,000	180,000	310,000
Fish	25,000	145,000	210,000	75,000	90,000	80,000	120,000	No data	200,000	180,000	125,000
Birds	180,000	250,000	2,250,000	500,000	315,000	270,000	300,000	No data	200,000	660,000	550,000
Marine mammals	150,000	No survey	630,000	500,000	315,000	270,000	300,000	No data	650,000	530,000	370,000
Total planning phase	**545,000**	**585,000**	**4,290,000**	**1,500,000**	**980,000**	**700,000**	**810,000**		**1,250,000**	**1,550,000**	**1,355,000**
Construction phase											
Benthic flora and fauna	No survey	No survey	600,000	210,000	No survey yet	No survey yet	85,000	340,000	No survey	No data	175,000
Fish	No survey	No survey	105,000	40,000	No survey yet	No survey yet	90,000	250,000	No survey	No data	70,000
Birds	30,000	125,000	750,000	250,000	No survey yet	No survey yet	250,000	750,000	No survey	No data	300,000
Marine mammals	110,000	160,000	300,000	250,000	No survey yet	No survey yet	300,000	275,000	No survey	No data	200,000
Total building phase	**140,000**	**285,000**	**1,755,000**	**750,000**	**-**	**-**	**725,000**	**1,615,000**	-	-	**745,000**
Operation phase											
Benthic flora and fauna	280,000	230,000	1,200,000	425,000	No survey yet	No survey yet	No survey	No survey yet	200,000	No data	390,000
Fish data	150,000	75,000	210,000	75,000	No survey yet	No survey yet	No survey	No survey yet	190,000	No data	115,000
Bird data	410,000	460,000	2,250,000	500,000	No survey yet	No survey yet	No survey	No survey yet	575,000	No data	700,000
Marine mammal	265,000	280,000	600,000	250,000	No survey yet	No survey yet	No survey	No survey yet	325,000	No data	285,000
Total operation phase	**1,105,000**	**1,045,000**	**4,260,000**	**1,250,000**	**-**	**-**	**-**		**1,290,000**		**1,490,000**

4.5 Cost of data for development of offshore windmills till 2020

4.5.1 Number of wind farms planned to be built till 2020

The Member States and the European Wind Energy Association have projected an installed offshore wind farm capacity of 43 GW and 40 GW by 2020, respectively. The present capacity is 5 GW. Consequently, a capacity of 35-38 GW corresponding to 175-180 wind farms each with a capacity of 200 MW is assessed to be constructed by 2020.

This section will be further elaborated in the next version of the report, i.e. including details of construction for different Member States. The estimated costs presented here are averages based on the review of both operators' replies and literature information.

4.5.2 Costs of data

Estimated data costs for establishing 35-38 GW wind farm capacity in Europe by 2020 are shown in Table 4-9.

The estimation indicates that data costs of an offshore wind farm of 200 MW are in the order of EUR 19 million and with projected new capacity to be installed in the order of 35-38 GW, the total data costs in the sector could be in the order of EUR 3.4 - 3.7 billion. The major part of the total costs, are costs for geotechnical site surveys.

The costs of the geotechnical site surveys depend very much on the conditions at the specific location and they could vary with plus/minus EUR 5 million compared to the average estimates presented here. It means that the costs for one 200 MW offshore wind farm would be in the range of EUR 14 million to EU 24 million.

Table 4-9 Estimated costs of establishing 36-39 GW wind farm capacity in Europe by 2020

	Mean cost 200 MW Wind farm €	Costs till 2020 for establishing 35-38 GW Million €
Planning Phase		
Metocean data	740,000	130-141
Bathymetrical/geophysical/geo-technical data	1,800,000	315-342
Benthic flora and fauna data	310,000	54-59
Fish data	125,000	22-24
Birds data	550,000	96-105
Marine mammals data	370,000	65-70
Total planning phase	**3,895,000**	**682-741**
Construction phase		
Metocean data	43,000	7.5-8
Bathymetrical/geophysical/geo-technical data	12,900,000	2,258-2,451
Benthic flora and fauna data	175,000	31-33
Fish data	70,000	12-13
Birds data	300,000	53-57
Marine mammals data	200,000	35-38
Total construction phase	**13,688,000**	**2,397-2,600**
Operation phase		
Metocean data	66,000	12-13
Bathymetrical/geophysical data	145,000	25-28
Benthic flora and fauna data	390,000	68-74
Fish data	115,000	20-22
Birds data	700,000	123-133
Marine mammals data	285,000	50-54
Total operation phase	**1,700,000**	**298-324**
Grand total costs	**19,283,000**	**3,377-3,665**

5 Legal basis

5.1 Legal Assessment

The TORs for this study ask what legal basis could be used for a Directive or a Regulation on marine knowledge that meets several objectives, and whether there are any similar examples. The background for this separate analysis is that the Maritime Policy does not have an explicit legal basis under the TFEU. It has so far been assumed by DG MARE that a Regulation or a Directive on marine knowledge meets the objectives for environment, research, industry, transport, fisheries, etc., implying that justification for legal action may be found also within other policy areas.

The Marine Knowledge 2020 Communication pointed to data bottlenecks preventing investments in marine data and the need for multiple uses of marine data. The underlying problem to be addressed by the study is that Member States are generally not bound by a legal obligation to give wider access to data and information submitted by a private sector actor, which often leads to inefficient use of the existing data, resources and mechanisms to deliver a blue economy. Marine knowledge is needed both in licensing, design, construction and operation of offshore installations. The Green Paper currently in consultation has now opened a debate on the best strategy forward for reducing costs, stimulating innovation and reducing uncertainty. The Marine Knowledge 2020 strategy is thus fully aligned with the Commission's policy towards the re-use of public sector information (PSI) and the Commission's overall Digital Agenda for Europe.

According to the TORs, this study should focus on what legal basis could be used for a Directive or a Regulation on Marine Knowledge. Ongoing considerations in DG MARE are thus whether a multiple legal basis could be used for a Directive or a Regulation on Marine Knowledge due to the cross cutting nature of such an initiative.

Alternative options to a legal action presented solely by DG MARE have been considered as well. Considerations have thus been ongoing on whether an amendment to existing legislation would be a possible option forward, e.g. through amendments to the INSPIRE Directive (Dir. 2007/2/EC), the Public Access to

Environmental Information Directive (Dir. 2003/4/EC, the Aarhus Directive) and the Re-use of Public Sector Information Directive (Dir. 2003/98/EC, the so-called PSI Directive), complementing the Access to Information Directive. The alternative options are described further below.

DG MARE has also considered whether a possible legal basis in the Treaty could be the same as the ones used as legal bases in the proposal for a Regulation on European Maritime and Fisheries Fund (EMFF), COM (2011) 804 final, notably Article 42, Article 43(2), Article 91(1), Article 100(2), Article 173(3), Article 175, Article 188, Article 192(1), Article 194(2) and Article 195(2) TFEU According to information received from DG MARE; the Legal Service has indicated to the DG in the internal legal service process that the legal basis used in the EMFF would not be sufficient for a legal basis, as the EMFF only create a right but does not impose legal obligations.

Resort to multiple legal bases is also envisaged for the recently proposed Directive establishing a framework for maritime spatial planning and integrated coastal management (Spatial Planning Directive).[25] Specifically, the initiative is based on Articles 43(2) (fisheries policy), 100(2) (transport), 192(1) (environment) and 194(2) (energy) of the TFEU. The Directive seeks to coordinate different sectoral policies that have a bearing on maritime space so as to achieve not only the policies' individual objectives, but also jointly contribute to the sustainable growth of marine and coastal economies and the sustainable use of resources.

Although the overall aim of the proposed Spatial Planning Directive shares many of Marine Knowledge 2020's characteristics, it shall be emphasized that a legal basis for a measure does not depend on the legal basis used for the adoption of other EU measures, which might, in certain cases, display similar characteristics.[26] According to settled case-law, the legal basis for an act must be determined having regard to the measure's own aim and content.[27]

The general aim of Marine Knowledge 2020 is to improve marine knowledge and thereby contribute to sustainable growth in the interconnected global economy.[28] In order to achieve this goal, it is necessary to implement, integrate and coordinate various sectoral policies (e.g. fisheries policy, transport, environment, etc.), but also to build an effective European marine data infrastructure with the view to promote the interconnection and interoperability of national marine data networks (in particular Article 172 TFEU). In conclusion, the proposed Spatial Planning Directive shall be taken as a good starting point for the establishing of legal basis for a potential legislative act for Marine Knowledge 2020, but depending on the framing of options on such an act, resort to additional legal bases may be necessary.

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[25] COM(2013) 133 final.

[26] Case C-91/05 Commission v. Council [2008] ECR I-3651, para. 106.

[27] Case C-94/03 Commission v Council [2006] ECR I-1, para. 50.

[28] Communication from the Commission to the European Parliament and the Council, Marine Knowledge 2020 COM (2010) 461 final.

The study seeks in its recommendations to point to the most appropriate legal basis for a Directive or a Regulation, depending on the more exact framing of the final recommendations for action and the options that the Commission decide to take forward following the public consultation on the Green Paper.

For later impact assessment purposes, an impact assessment will traditionally have to look at the options for legal action:

- 1) the 'do nothing approach' meaning no changes to existing legislation
- 2) amending existing legal instrument(s)
- 3) new legislation
- 4) An additional option to be considered could be soft law measures, e.g. guidance or technical formats, recommended licensing provisions or guidance on price calculations. A fifth option could be one combining the above options.

5.2 Initiatives with multiple legal bases

5.2.1 The main rule on legal bases

In the EU law, the clear main rule is that any new legislative initiative needs to be based on a single legal basis of the Treaty. In view of the consequences of the legal basis in terms of substantive competence and procedures, the choice of the correct legal basis is of constitutional importance.

Further, in accordance with case-law of the Court of Justice, the choice of legal basis for a Community measure must rest on **objective factors amenable to judicial review, including in particular the aim and the content of the measure**.

As regards multiple legal bases, if examination of a EU measure reveals that it pursues a twofold purpose or that it has a twofold component and if one of those is identifiable as the main or predominant purpose or component, whereas the other is merely incidental, the act must be based on a single legal basis, namely that required by the main or predominant purpose or component. [29]

On the other hand, where a measure has **several contemporaneous objectives or components** which are indissolubly linked with each other without one being

[29] Case C-42/97 Parliament v Council [1999] E.C.R. I-868, paras. 39-40; Case-C 36/98 Spainv Council [2001] E.C.R. I-779, para. 59; Case C-211/01 Commission v Council [2003] E.C.R.I-8913, para. 39

secondary and indirect in respect of the others, the measure must be based on the various relevant Treaty provisions.[30]

Examples of related legislative measures with single legal basis are:

Legal instrument	Legal Basis
Maritime Strategy Framework Directive (Dir. 2008/56/EC)	Article 175(1) TEC
Recommendation on EU Integrated coastal zone management (ICZM)	Art 175(1) TEC
Access to Information Directive (Dir. 203/4/EC)	Article 175(1) TEC
INSPIRE Directive (Dir. 2007/2/EC)	Article 175(1) TEC
Re-use of Public Sector Information Directive (Dir. 2003/98/EC, the so-called PSI Directive	Article 95 TEC New proposal for amendment under Article 114 TFEU

As described above, certain exemptions from the main rule can be made in situations with multiple and equal purposes of the relevant instrument. A few examples are:

Legal Instrument	Legal Basis
Regulation (EU) No 1255/2011 of the European Parliament and of the Council of 30 November 2011 establishing a Programme to support the further development of an Integrated Maritime Policy	Articles 43(2) - Fisheries, 91(1) and 100(2) - Transport, 173(3) - Industry, 175 –Territorial Cohesion, 188 – Research, 192(1) - Environment, 194(2) –Energy and 195(2) – Tourism of the TFEU
Proposal for a Regulation on European Maritime and Fisheries Fund (EMFF) under the 2014-2020 framework COM (2011)804 final	Article 42, Article 43(2), Article 91(1), Article 100(2), Article 173(3), Article 175, Article 188, Article 192(1), Article 194(2) and Article 195(2) TFEU
Proposal for a Directive establishing a framework for maritime spatial planning and integrated coastal management COM (2013) 133 final	Article 43(2), Article 100(2), Article 192(1) and Article 194 (2) TFEU

5.3 Alternative options

Alternative options to a legal action presented solely by DG MARE have been considered e.g. through other existing legal instruments. Considerations have thus been ongoing on whether an amendment to existing legislation would be a possible option forward, e.g. through amendments to the INSPIRE Directive (Dir. 2007/2/EC), the Public Access to Environmental Information Directive (Dir. 2003/4/EC, the Aarhus Directive) and the Re-use of Public Sector Information

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[30] Case C-165/87 Commission v. Council [1988] E.C.R. 5545, para. 11; Case C-178/03 Commission v. European Parliament and Council [2006] E.C.R. I-107, paras. 43-56.

Directive (Dir. 2003/98/EC, the so-called PSI Directive), complementing the Access to Information Directive.

The **INSPIRE** Directive only regulates the exchange, sharing, access and use of interoperable spatial data and spatial data services across the various levels of public authority in their performance of their public tasks; thus not the sharing of data between the public and the private sector. Subject to certain conditions, the Directive may also apply to spatial data held by natural or legal persons other than public authorities, provided that those natural or legal persons request this. By way of derogation, MSs may limit public access to data, e.g. due to intellectual property rights; or the confidentiality of personal data and/or files relating to a natural person where that person has not consented to the disclosure of the information to the public, where such confidentiality is provided for by national or Community law.

The **Aarhus Directive** and the **PSI Directive** allow in principle for the private sector to get access to the data publicly available. However, uneven practical implementation of the Directives by the Member States and lack of harmonisation amongst Member States regarding the re-use of public data have so far hindered a better sharing of data.

The aim of the PSI Directive (2003/98/EC) is to facilitate the re-use of PSI by harmonising the basic conditions for reuse and removing major barriers to re-use in the internal market. The original Directive thus contains provisions on non-discrimination, charging, exclusive arrangements, transparency, licensing and practical tools to ease and facilitate the discovery and re-use of public documents.

The PSI Directive does not contain an obligation to allow re-use of documents, thus the decision whether or not to authorise re-use remains with the Member Sates or the public sector body concerned. At the same time, the Directive builds on national rules on access to documents. Some Member States have expressly linked the right of re-use to this right of access, so that all generally accessible documents are re-usable. In other Member States, the link between the two sets of rules is less clear and this is a source of legal uncertainty.

The Communication COM(2009) 212 and the following 2011 Commission proposal for amending the PSI Directive clearly pointed to existing barriers such as the lack of information on available PSI, and public sector bodies failing to realise the economic potential linked with re-use of data. Thus, a need for a re-enforcement of the PSI Directive was identified to overcome these barriers, e.g .lack about what data are actually available, restrictive or unclear rules governing access and re-use conditions, discouraging, unclear and inconsistent pricing where the re-use of information is chargeable, and the overall excessive complexity of the process for obtaining permission to re-use PSI. The proposal for an amended Directive clearly states the need for an optimal legal framework to facilitate and stimulate the commercial and non-commercial re-use of public open data removing regulatory and practical borders for re-use, so that the same types of data are available on similar, if not the same, terms and conditions irrespective of their national origin.

As pointed out by the Proposal text, currently in first ordinary legislative reading in the Parliament, the intention of the amendment to Directive 2003/98/EC is thus to lay down a clear obligation for Member States to make all generally available documents re-usable. As it constitutes a limitation to the intellectual property rights held by the authors of the documents, the scope of such a link between the right of access and the right of use should be narrowed to what is strictly necessary to reach the objectives pursued by its introduction. In this respect, documents on which third parties hold intellectual property rights should be excluded from the scope of Directive 2003/98/EC. If a third party was the initial owner of a document that is still protected by intellectual property rights, that document should, for the purpose of this Directive, be considered as a document for which third parties hold intellectual property rights. The revision of the Directive is thus not to regulate the right of access to public documents, which remains the sole and exclusive competence of Member States, but the revised provisions would apply to the re-use of documents where these are generally accessible, also under national access rules.

Amendments to the INSPIRE and Access to information Directive will thus have to be based on Article 192 TFEU whereas the new proposal for amendment of the PSI Directive is based on Article 114 TFEU (Internal Market).

5.4 Tentative conclusions and possible way forward

The following scheme shows at this early stage of the process the possible ways forward, following the consultation on the Green Paper. Further detailed analysis in relation to the legal basis will depend on the more exact framing of options, as indicated below.

Option	**Impacts (positive/negative)**	**Legal basis**
1. A 'do nothing approach' meaning no changes to existing legislation	Increasing uneven implementation at MS level regulatory uncertainty and no reduction of costs/ continued distortion of competitive conditions/Internal Market and thus not sufficient stimulation of innovation	As before
2. Amending existing legal instrument(s)	Depends on clearer framing of options on legal measures. The assumption is that a legal initiative will lead to greater legal certainty, reduction of costs due to the economic importance of open data including reduction of competitive market hindrances as well as increased stimulation of innovation.	Changes to the existing legislative acts will have to be made within the same legal basis of the Treaty.
3. New legislation	Depends on clearer framing of options on legislative or non-legislative acts. The assumption is that it will bring about enhanced legal certainty, lowering barriers for re-use of data and thereby	Legal basis for horizontal measures needs to be identified and agreed, either within existing legal Treaty basis for EU maritime policy or within the legal basis for horizontal environmental measures, depending on the framing of the exact

Option	Impacts (positive/negative)	Legal basis
	reducing costs.	option. In the case the options will identify legislative acts according to Art 288 TFEU (Regulations, Directives or Decisions) the ordinary legislative procedure in Art 294 TFEU shall be applied. Non-legislative acts will either have to be based on the Treaties or based on secondary legislation/implementing acts based on implementing powers procedure - 'comitology'- (Art 291 TFEU) or through adoption of delegated acts through delegated power to the Commission (Art. 290 TFEU)
4. Soft law measures	May to some extent facilitate application of the rules of the PSI Directive on licensing and charging. Will however not necessarily improve the uneven implementation at MS level to the same degree as with a legal action, so regulatory uncertainty and distortion of competitive conditions may still occur at the same scale.	Legal basis can be found within existing legal basis for EU maritime policy, as before.
5. One to more combinations of the above options ("package solution").	Depends on clearer framing of options on specific package. The assumption is that combining legal amendments with soft law measures will bring together the benefits from options 3 and 4 above and thus provide enhanced legal certainty, removal of barriers for promoting re-use of data, reducing costs and stimulating innovation.	Legal basis for horizontal measures needs to be identified and agreed, either within existing legal basis for EU maritime policy or within the legal basis for horizontal environmental measures, depending on the framing of the exact option.

6 Innovation from marine data

6.1 Objectives

One of the key objectives of improving marine knowledge is to increase competitiveness and innovation amongst users and re-users of marine data by providing wider access to quality-checked, rapidly available, coherent marine data. Knowledge is a key component of the EU's plan to integrate marine and maritime research and a contribution to the Digital Agenda.

The Impact Assessment of 2010 demonstrated that the current inability of researchers and private companies to access marine data to develop new products, services, processes or commercialisation techniques is blocking innovation, at an estimated worth of between € 60 and € 200 million annually.[31]

Furthermore, improved marine information regarding the behaviour of the sea or the state of the seabed and marine life has the potential to reduce uncertainty, thereby reducing costs, providing new opportunities to use resources in a sustainable manner, and encouraging innovation.

The objective of this study is to identify examples of innovation in products, services, processes and/or commercialisation techniques that could be positively impacted by improved marine knowledge. It relates to questions 12 to 15 in the Terms of Reference, outlined below:

> *"Assuming that historic and real-time data were available on parameters such as chemical pollution, non-native species, coastal erosion, storm intensity etc what services based on these and other data:*
>
> *a) might reduce risks for aquaculture producers?*

[31] European Commission, *Marine Knowledge 2011-2013: Background Document for Maritime Policy Member States' Expert Group on Marine Knowledge*, 23 February 2011

b) *might enable insurance companies in coastal regions to provide a better assessment of risk?*

c) *could support a longer season for coastal tourism?*

d) *could help the bio-economy discover new products (pharmaceuticals, enzymes, cosmetics etc)"*

Three examples of possible services in each of these four cases have been provided, in addition to three examples chosen by the contractor.

6.2 Methodology applied

This section presents a number of case studies that provide specific examples of potential innovations that could benefit from improved knowledge. The methodology applied for developing the case studies is outlined below.

› Initial brainstorming of ideas: based on EC publications, the terms of reference and desktop research, a list of potential ideas was developed, for the basis of further in detail research

› In depth desktop research on EC publications, research projects, academic articles regarding past and present initiatives: based on the initial list, potential ideas were investigated through a review of academic articles, research projects and other publications. This process also assisted in the identification of potential sector specialists that could be consulted to validate the ideas developed.

› Drafting of case study examples: the thorough research was then developed in the form of a case study document, which was organised as follows:

  › Case presentation: problem definition and opportunities, providing an explanation of context and situation in Europe

  › The need for marine knowledge in Europe: explanation of the current state of knowledge, any existing knowledge/research initiatives, the types of data that may be needed to realise the benefits, and the connection to Marine Knowledge 2020

  › Innovative service/product and benefits: explanation of the current/future service/product to be developed, and estimations of the economic benefits associated with the innovation

  › Data sources, bibliography, and list of interviews / input received

› Interviews with specialists identified through desktop research: once a draft case study document had been developed, contact was made with identified specialists in order to discuss the content and assumptions in the case study.

For each case study example, the contractor has sought to consult at least one sector specialist.

- Incorporation of comments and finalisation: following additional desktop research and specialist interviews, the case studies were finalised.

6.3 Limitations

The identification of potential innovations that could result from improved marine knowledge and their quantification in terms of economic benefits has required a number of assumptions to be made. The limitations of this part of the study are outlined below.

- Largely based on existing documentation and studies: the identification of examples and their development into case studies is predominantly based on existing documentation and studies publicly available.
- Extrapolations of specific quantitative examples: due to the nature of the case study examples, examples of quantitative benefits have been extrapolated where possible and relevant, based on assumptions.
- Specific examples that may not reflect the entire opportunities for sector: due to the fact that three case study examples have been sought for each of key sectors, they do not necessarily reflect all the opportunities and economic benefit for a given sector.
- Specialists do not necessarily represent the views of the entire sector: the specialists have been identified through the desktop research process, and whilst their views provide important input and validation of the case studies presented, their views may not represents the entire sector.
- Challenge in isolating the particular impact of “improved marine knowledge” in the development of an innovation or sector: whilst the identification of innovative products and services may be possible, it is challenging to identify the particular impact that improved marine knowledge would have on the innovation.
- Challenges associated with the quantification of benefits: it is worth reiterating that this exercise has been necessarily quite speculative and hypothetical – the benefits derived from improved marine knowledge may be largely indirect, and therefore difficult to define and quantify.
- Finally, in terms of quantifying monetary benefits, the extrapolation of collected data has been challenging and should therefore be handled and interpreted with caution. The output for this question is largely qualitative case study examples, with quantitative estimates where possible. Economic modelling was not feasible within the context of this study and its timeframe.

6.4 Summary findings

Detailed case studies for the examples identified are provided in the subsequent sections. The table below summarises the findings of these case studies, in terms of the importance of marine knowledge/data and a demonstration or estimation of the economic benefits.[32]

Improved marine knowledge, whether it be through better sharing of datasets on past and present events, improved coordination of research efforts, or other types of specific phenomena, can bring potentially significant economic, social and environmental benefits.

These benefits can be realised through the creation of innovative services and encourage the growth of emerging sectors, through the mitigation of risks and negative impacts, or through a reduction in uncertainty regarding the state of the oceans and seas. The benefits are therefore expressed in a number of different manners, which include:

- Avoidance of revenue/production losses
- Increase in profitability
- Reduction in costs
- Regional economic impacts.

[32] For currency conversion, the follow assumptions have been made: $US1 = €0.78 and £1 = €1.17.

Table 6-1 Case study examples of innovation

Title	Hypothesis	Data needs	Economic benefits
Reduced risk to aquaculture production			
Early warning device for jellyfish blooms	Limited knowledge regarding the reasons for blooms, their impacts and potential mitigation strategies. An early warning system to anticipate blooms and better understand behaviour and impacts, and minimise damage to aquaculture production.	Widespread monitoring to obtain site-specific data on jellyfish populations, including their seasonal occurrence and abundance. Need to coordinate research at a regional level, and share results of studies.	Assuming that half of the 12% mortality rate due to gill disorders[33] can be attributed to jellyfish, and that the affected species are mostly Mediterranean mussels, as well as northern rainbow trout and salmon production (€1.4 billion market in 2009)[34], **addressing jellyfish impacts could assist in avoiding losses to production of € 84 million** (1.4 billion x 6%).
Offshore aquaculture: new sea-cage design	Expansion of offshore aquaculture requires cages designed to withstand extreme conditions, protect against invasive species, and production losses (escapes) and keep maintenance costs low.	Hydrographical data to optimise cage location, data on the structure and quality of the seabed, meteorological data to predict waves, currents, and information on past extreme weather events and real time monitoring.	New cage design could lower production costs through fewer visits, and minimising risk of fish escape. A study of the "Economic Feasibility and Impact of Offshore Aquaculture" in the Gulf of Mexico[35] provides an idea of the potential of the offshore aquaculture sector through improved cage design. This study concluded that a single farm operation directly employing only seven individuals for offshore production can provide an **additional annual regional economic output (direct, indirect, and induced effects) of at least $US 9 million (€7 million) and provide additional employment for at least 262 persons**, related to processing, feed production, distribution, etc.
Understand and address ocean acidification	Ocean acidity has an impact on the ecosystem, but it is not well understood. Understanding ocean acidification, and the impact it has on shellfish will assist in predicting and minimising further negative impact on the ecosystem (global observation network).	Data on behaviour of flora and fauna to changes in acidity, comparable paleo-data (past events and impacts), time-series data, real time monitoring data. Stronger links between research and industry.	Economic costs of reduced mollusc production due to ocean acidification in the EU 15 (at the time of study) will be **at least $US 500 million (€ 375 million) in 2100 under a business-as-usual scenario**.[36] This estimation of economic impact is only based on mollusc production. But because molluscs are the basis of many other fish feeding chains, the global impact of acidification in aquaculture (capture) should be even greater.

[33] Baxter, E., Rodger, H., McAllen, R., Doyle, T. (2011), "Gill disorders in marine-farmed salmon: investigating the role of hydrozoan jellyfish", Aquacult Environ Interact, Vol. 1: 245–257, 2011

[34] Facts and Figures on the Common Fisheries Policy, 2012 edition, DG MARE

[35] Posadas, B. C., and C. J. Bridger. 2005. Economic Feasibility and Impact of Offshore Aquaculture in the Gulf of Mexico. MASGP 04---. In Bridger, C. J. (ed.). Efforts to Develop a Responsible Offshore Aquaculture Industry in the Gulf of Mexico: A Compendium of Offshore Aquaculture Consortium Research. Mississippi-Alabama Sea Grant Consortium, Ocean Springs, MS

[36] Economic Costs of Ocean Acidification: A Look into the Impacts on Shellfish Production, Daiju Narita, Katrin Rehdanz, Richard SJ Tol, 2011

Better assessment of risk for insurance companies			
Insurance discounts through improved marine safety information	Through more reliable nautical charts and maritime safety information, insurance providers may be willing to offer products with reduced premium's resulting in lower insurance costs, which is a major operating cost factor for shipping companies.	Improved quality nautical charts – including topographic data, seabed features, and navigational hazards – as well as better coverage of open seas through hydrographical surveys. Meteorological data in order to anticipate natural events and protect both hull and cargo.	Marine insurance premiums are known for their volatility, with a complex array of internal and external drivers acting. However, improved navigational technology, owing, in large part, to greater availability of marine data, has significantly reduced risks associated with this industry. As an illustration of economic benefits associated with marine data, there is an agreement between a US marine system software company and insurance provider whereby **customers whose vessels are equipped with the MICAD Marine System** (a real-time marine data collection and management system which includes information, diagnostics, satellite communication, vessel and fuel management, and permanent archival of vessel data on each individual vessel or an entire fleet) **are offered a 20% discount on insurance products**.[37]
Managing natural disaster risk in Europe's coastal regions	Costs of weather-related natural disasters have been rising and in large part due to climate change. Data is highly fragmented and of little use for climatologists and actuaries seeking to better understand and plan for the effects of climate change.	Type of data needs can vary depending on the type of analysis and the disaster likely to occur – e.g. monitoring activities in flood prone needs rain-fall data, water level telemetry stream flow and storm surge, whilst climate change modelling needs reliable time-series data on a span of climatological indicators. There is a need for metocean data that is already widely collected by industry and public authorities, as well as coastal monitoring data on phenomena such as coastal erosion and flooding.	Economic benefits of improved risk assessment can be substantial in the long run. With losses in 2011 in Europe totalling over $US 9 billion (€7 billion), strategic investments in adapting Europe's coastal regions could result in **hundreds of millions in economic benefit**. For instance, if better modelling and monitoring allowed coastal adaptations to be only slightly more effective, **losses could be reduced by millions annually**. While this estimate is crude and does not take into account more unquantifiable benefits such as the long-term health of Europe's insurance industry, it gives an idea of how small investments may make a huge impact.
Improving the certification process for offshore wind projects	In a sector evolving at such a fast pace, underwriters can be hesitant about extending certain types of coverage to innovative designs. Independent certification provides outside assurance.	While more widely available metocean data cannot replace site specific data collection, as crucial environmental parameters can vary drastically over short distances in marine environments meaning developers need a 'high resolution picture' of the specific site, it could be highly valuable at other stages of the certification process, such the conceptual design phase and elaborating an effective maintenance strategy.	Insurance has an important role in supporting investment in offshore wind projects by providing security for investors. In the future, there is the risk of inadequate coverage for the level of investment needed. Certifying designs and subjecting prototypes to rigorous testing using marine data, particularly metocean data, will thus play an important role in **allowing underwriters to keep up with technological advances**. Furthermore, predicting remaining useful life under normal operating conditions will **allow operators to better manage their assets and adapt up-keep and maintenance strategies**. Quantitative estimatations of benefits for this example however were not feasible.

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Extend the coastal tourism season			
Coastal cleanup and awareness raising to attract and develop sustainable eco-tourism	Mitigate the negative impact of increased tourism flow, by raising public awareness. Minimise the impact on marine life and habitats through sustainable eco-tourism solutions.	Meteorological data, data on water quality, coastal erosion. Observation of movement of species, and their habitats. While, on the EU level, there is the Marine Strategy Framework Directive, a coherent framework for the systematic use of this data within the context of coastal development has been lacking.	Due to a lack of specific data on the eco-tourism industry, it is difficult to provide sound estimate for the growth potential of this market in Europe. However specific examples indicate benefits. A US study found the **economic benefits of improving beach water quality could increase the number of visitors by 1,538 visits per year for a total economic impact (local spending) of $US 45,000/year (€35,000/year) (at one beach).**[38] Water quality issues are estimated to impact the tourism industry in Blackpool, UK, **facing losses of £ 1 billion (€1.17 billion) over 15 years**. According to an EU survey in 2010, 500 EU beaches did not reach minimum quality standards. There is potential therefore that cleanup may **result in avoided losses of up to €585 billion over 15 years**.
Artificial reefs: surf and diving opportunities	Artificial reefs have the potential to increase sustainable coastal tourism through surf and diving revenues, but also protect marine species and therefore create potential dive and game fishing sites.	Bathymetry and topography, marine currents and meteorology, quality of water and salinity: to optimise location, material used and reduce impacts on environment	US studies have found that depending on its size and the method used, creating an artificial reef can cost from $US 46,000 to $US 2 million (€35,000 to €1.5 million).[39] In Florida, where there are some **2700 artificial reefs**, a study found that **non-residents and visitors annually spent $US 1.7 billion (€1.3 billion) on fishing and diving activities associated with artificial reefs**.[40] Similar potential may be possible for the EU.
Protection against coast erosion	Better coastal protection will save on structural damage and insurance costs, as well as enable sustainable management of tourism growth, minimising impact.	Data on past observations of meteorological events, current water flows, winds, water temperature, topography, bathymetry and human activity impacts to prepare an appropriate response to erosion.	Protecting against coastal erosion can provide very direct economic benefits, including lowering insurance premiums, saving productive coastal land and protecting tourist destinations that provide a crucial injection of revenue for many coastal economies. Beyond these direct benefits, there are also less tangible benefits. For example, a Portuguese study by Alves *et al*, using the Benefit Transfer approach, found that the **total value of coastal ecosystem services in central Portugal amounted to € 193 million annually and that expected ecosystem service value losses amount to € 45 million by 2058**.[41]

[38] http://surfeconomics.blogspot.co.uk/2009/11/cost-of-poor-water-quality-at-surfrider.html
[39] Pendleton ‘Understanding the Potential Economic Impacts of Sinking Ships for SCUBA Recreation’. 2005.
[40] ‘Adams, Lindberg & Stevely ‘The Economic Benefits Associated with Florida’s Artificial Reefs’. 2006, 2011 (revised)
[41] Alves, Roebling, Pinto & Batista ‘Valuing Ecosystem Service Losses from Coastal Erosion Using a Benefits Transfer Approach: A Case Study for the Central Portuguese Coast’. Journal of Coastal Research n 56, 2009.

Discovery of new bio-economy products			
Development of seaweed based products	Localising natural resources and a more stable cultivation process of algae will maximise the benefits for potential growth markets.	The potential economic return of cultivated algae is unknown, as there is a lack of long term trial data. Data on the location and availability of natural stocks based on prediction models and observations.	Given the two main potential markets that are bioenergy and biomaterials, the economic benefits of products based on seaweed are potentially very high. Nonetheless, it is difficult to estimate the economic benefit for potential uses at an early stage of development. As an example, **Irish seaweed production and processing sector will be worth € 30 million per annum by 2020** (the sector is currently worth € 18 million per annum).[42] In order to reach this target, there is a need to capitalise on the existing wild resources and augment supplies of high value seaweeds. Similar growth projects may be possible for other Member States if better data is available to develop the sector.
Innovation aquatic pharmacy products	Biotechnology companies looking for pharmaceuticals / enzymes to catalyse industrial processes need to know where to look. Data to locate these organisms has the potential to unlock the economic potential associated with new discoveries.	Bioprospecting, greater knowledge of sediments, habitats and sea-floor topography to better target scientific exploration. Extensive taxonomy of marine organism in order to create biobanks: type, focus and taxonomy of organisms, amount available, format.	The global market for marine-derived drugs was $US 4.8 billion in 2011 and is expected to be $US 5.3 billion in 2012. According to BCC Research, this **global market is forecasted to reach $US 8.6 billion (€6.7 billion) in 2016** at a compound annual growth rate of 12.5 % for the five-year period of 2011 to 2016.[43] Furthermore, 2011 research by BCC Research found mollusc to be the fastest growing market for marine-derived drugs, **expected to grow from $US 69.4 million in 2011 to $US 490.1 million (€382 million) by 2016** at a CAGR of 47.8%.[44]

[42] A Market Analysis towards the further development of Seaweed Aquaculture in Ireland, Máirtín Walsh, Lucy Watson, BIM
[43] "Global Markets for Marine – Derived Pharmaceuticals" cited in Market Research Reports and Technical Publications Product Catalog December 2012, http://www.bccresearch.com/report/marine-derived-pharma-markets-phm101a.html
[44] "Global Markets for Marine – Derived Pharmaceuticals" cited in Market Research Reports and Technical Publications Product Catalog December 2012, http://www.bccresearch.com/report/marine-derived-pharma-markets-phm101a.html

Protecting Biodiversity for Tomorrow's Blue Economy	Biodiversity is crucial for the health of ecosystems. Furthermore the genetic diversity of undiscovered marine resources offers an inestimable stream of future innovation for the blue biotechnology sector. In order to better manage ecological security and ensure a flow of future innovation, researchers and policy makers must first be able to better understand and measure biodiversity.	Biodiversity data comes from a wide spectrum of sources and goes beyond populations of specific species. It also requires data to feed indicators on phenomena such as pollution, non-native species, eutrophication, etc… Developing new tools and methods to measure the health of ecosystems and new modes of cooperation in order to improve the cost-effectiveness of gathering and analysing environmental data are key challenges for better policy making in Europe. Understanding and internalising the economic 'cost' of losing biodiversity will also act as a driver for better decision making.	While assigning economic value to ecosystem and biodiversity may seem reductive, the exercise can provide a sense of what Europeans stands to lose from future changes in biodiversity, although it glosses over ethical considerations such as the intrinsic or 'non-use' value of natural resources. Undiscovered species under threat of extinction, while they may have **little economic 'use value' can hold astronomical 'option value'** in that they may hold keys to future scientific advancement. For example, **significant value ($US 230–330 million[45] (€180 to 260 million)) has been attributed to genetic information gained from preventing land conversion** in Jalisco, Mexico, in an area containing a wild grass, teosinte (Euchlaena mexicana), that can be used to develop viral-resistant strains of perennial corn.
Other cases			
Sea-bed mining, mineral resources	By improving our understanding of the seafloor ecosystem, in terms of vulnerability, resilience and functioning of marine biodiversity, this can reduce the risks of seabed mining and potentially lead to development of commercial deep sea mining sector.	Further basic research on 'what lives where' and what affects the patchy nature of deep sea biotic distributions is needed to advance our understanding of this unexplored marine diversity and its associated biogeographic classifications. Data needs include seabed substrata, deep sea life, currents, etc to plan extraction, design instruments and understand behaviour of lifeforms.	Without better marine knowledge, the risks and costs of deep sea mining far outweigh the potential economic benefits. An example of the potential economic benefits of deep sea mining is the Solwara 1 deep-sea mining project in Papua New Guinea. This project was due to commence in 2014, and it is estimated that it would bring in more than **$US 140 million (€109 million) to Papua New Guinea's economy in its first two years of operation and claim that about 70 per cent of the project's staff would come from the country**.[46] However there are concerns it will result in the destruction of a still unexplored ecosystem. These concerns need to be better understood, in order to weight up the costs against the potential benefits.

[45] Fisher, A. C. & Hanemann, W. M. Option value and the extinction of species. Adv. Appl. Micro-Econ.4, 169–190 (1986)
[46] Sarmiento, P. "Should deep-sea mining go ahead in Papua New Guinea?", January 2013

Data to optimise offshore wind energy yield	Current knowledge gaps lead to underestimation of energy yield. Better predicting energy yield can assist in improving site selection and therefore potential productivity of industry.	Information required includes wind data, air intensity, turbulence intensity, topography, in order to provide accurate wind energy estimations.	A better assessment of energy yield will have a **positive impact on the investment case, resulting in more confidence in project financing, reduction in cost through optimisation of site selection, and increase in potential production**. However quantifying the benefits are very difficult to estimate, given a lack of quantitative studies in this area. This said, it has been recognised that **innovation opportunities over the next 10 years can bring down the deployment costs of offshore wind by up to ~25%, with further savings after 2020 likely to bring down costs even further (up to circa 60% by 2050)**.[47]
Optimisation of turbine foundation design	Foundation costs can represent up to 40% of wind capital expenditure on offshore wind. The sharing of data from experimental offshore installations can help researchers validate new types of more cost-effective foundations.	Measured data from experimental offshore installations (different structures and technologies) to validate existing models. Quality time series on sea-state parameters, currents, sea surface elevation, also soil characteristics.	Cost effective design optimisation of turbine foundation means that installations can be installed more economically. An example in the UK suggested that **minor design changes could lead to significant savings in construction schedule and costs**. The designers decided to make minor modifications to the monopile by welding a flange to which the wind tower could be bolted thereby getting rid of the transition piece and the expensive grouting used to connect it to the monopile altogether.[48] However for this given example, quantitative estimates of the benefits in terms of cost and time savings have not been established.

[47] Technology Innovation Needs Assessment (TINA), Offshore Wind Power Summary Report, Innovation Coordination Group, 2012
[48] http://cdn.intechopen.com/pdfs/14804/InTech-Selection_design_and_construction_of_offshore_wind_turbine_foundations.pdf

6.5 Case studies on innovation

6.5.1 Reduced risk to aquaculture production

Case 1: Early warning device for jellyfish blooms

Case presentation: problem definition & opportunities
Overall context
The study of jellyfish blooms is a topical issue, due to an apparent increase in the size and frequency of jellyfish blooms in coastal and estuarine waters around the world in recent decades. These blooms have captured the interest of scientists, as there is limited knowledge regarding the reasons for the phenomenon, its impacts and potential mitigation strategies. There are, without doubt, associated ecological consequences on the food web. Moreover, there are socio-economic impacts including damage to aquaculture production, fisheries, industry and tourism. However to date, studies have tended to be local or regional in scope, and there has been no concerted effort to monitor this phenomenon on a European level. As a result, a broad understanding of the extent of the problem in different geographical areas is still lacking. There is a need for collaborative effort and the exploitation of existing infrastructure in order to turn efforts towards better understanding the phenomenon and mitigating its impacts.
Situation in Europe and internationally
Jellyfish blooms have caused many problems in Europe in recent years. They have been known to clog fishing nets, cause mass mortalities of farmed salmon, or block the cooling water intake of power stations. They are also suspected to prey on certain fish eggs and larvae, thus limiting the potential recovery of already weakened fish stocks. Blooms have been observed in the Mediterranean sea, the Baltic sea and the North East Atlantic sea, especially in the Celtic Seas. A few examples of European jellyfish bloom phenomena have caused large-scale destruction: › The entire Irish salmon industry was wiped out in 2007 after a plague of billions of mauve stingers – covering an area of 10 sq miles (26 sq km) and 35ft (11m) deep – attacked the fish cages. › In the Mediterranean basin, jellyfish blooms have become a regular phenomenon over the last ten years[49], negatively impacting fishermen and aquaculture producers.

[49] CIESM (Mediterranean Science Commission), CIESM JellyWatch Program http://www.ciesm.org/marine/programs/jellywatch.htm

In the Mediterranean basin, the main threat is to shellfish production. This could have devastating consequences, given that in 2009, Mediterranean mussels represented in volume a quarter of the total aquaculture production in the European Union and 6% in value.[50]

In the North Sea, the most threatened species are rainbow trout and salmon, which in 2009 represented 29% of the total production in volume and 37% in value.[51]

The problem is also significant in regions outside Europe. As an illustration, perhaps the most extraordinary blooms have been those occurring in waters off Japan. Giant jelly fish called Nomuras, weighing over 220 kg and measuring 2m in diameter, have swarmed the Japan Sea annually since 2002, resulting in an economic loss to the Japanese fisheries industry in 2005 of 30 billion yen.[52]

The need for marine knowledge in Europe

Current knowledge

The causes of jellyfish blooms are not well known, and a number of potential causes have been cited in various studies. Some believe that population explosions result from overfishing of their competitors in the marine food web and predators, which include more than 100 species of fish, and animals such as turtles. Other researchers believe the blooms are due to a global warming of some seas, which result in a faster reproduction cycle. Finally, some believe that higher water pollution is indirectly linked to jellyfish blooms, as jellyfish feed off smaller crustacean who feed off algae generated in polluted waters.

Because of the magnitude and the impact these jellyfish blooms can have on all human activities, there have been many studies on the drivers of, and impact of jellyfish blooms on pelagic environments. There have been fewer studies to assess the impact of jellyfish detritus on pelagic and benthic ecosystems. Unfortunately, ground fish surveys through fishery observer programmes and assessments have not tended to collect data on jellyfish that are caught in the process, which is a lost opportunity to collect data.

Because this problem is global, many studies have been undertaken in Europe (Ireland, Scotland, Norway), the United States, Japan and Korea (see bibliography).

Existing initiatives

A number of data collection projects have been established in an effort to improve the understanding of jellyfish blooms, potentially develop an early warning system, and then establish real mitigating measures. There could be benefit in both sharing the outcomes

[50] Eurostat
[51] Eurostat
[52] Stone, R. (2011), "Massive Outbreak of Jellyfish Could Spell Trouble for Fisheries", http://e360.yale.edu/feature/massive_outbreak_of_jellyfish_could_spell_trouble_for_fisheries/2359/?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed\%3A+YaleEnvironment360+\%28Yale+Environment+360

of these studies and through undertaking research in a more coordinated manner.

A few examples of initiatives in Europe and the United States include:

- The EcoJel project: this project involving the Swansea University (Wales) and University College Cork (Ireland) was undertaken between 2008 and 2012, and financed by ERDF INTERREG. Its objective was to assess the opportunities and detrimental impacts of jellyfish in the Irish Sea. It allowed the development of a user-friendly application for users to report sightings of jellyfish around Ireland.
- ECOGEL[53]: this project was funded under the FP5 programme and focused on identifying and quantifying key factors regulating jellyplantkon abundance and succession. Key results of the research include the production of a Jellyfish Identification chart (common or problem jellyfish of the British Isles) for fish culturists, harvesters and marine life enthusiasts, as well as a video recording system for estimating the abundance, distribution and population structure of jellyfish in surface waters.
- CIESM Jelly Watch programme: the Mediterranean Science Commission set up this programme in 2008 to gather for the first time baseline data on the frequency and extent of jellyfish outbreaks across the Mediterranean Sea. Because the pilot phase proved successful in 2009, it is now being extended to the whole of the Mediterranean Basin.
- The Crown Estate in Scotland funded a study in 2010 called Developing the capacity to monitor the spatial and temporal distributions of jellyfish in western Scottish waters. In this survey, aquaculture production industry actors were interviewed in order to establish the sightings they had of jellyfish.
- The Jellywatch programme was started in the United States in 2009, it went public in 2010. This project aims to create a scientifically coordinated global jellyfish and environmental database based on already identified datasets from coastal, estuarine and open-ocean regions: the data collected is from all around the world. This two year project was started by the Monterey Bay Aquarium and Monterey Bay Aquarium Research Institute. It involves data acquisition and statistical analyses, global synthesis of trajectory maps of regional jellyfish blooms, generation of conceptual diagrams of the role of jellyfish in biogeochemical cycles and food webs, and discussions relating to the socio-economic ramifications of jellyfish blooms.

Other initiatives include studies on cage design optimization, through potentially producing a bubble curtain around a cage, to keep jellyfish out whilst avoiding environmental impacts. Other types of early warning systems are being investigated, so that the alarm is raised when jellyfish are present in nearby waters.

Furthermore, attempts have been made to develop an Atlantic Jellyfish Monitoring programme to pool data through the INTERREG programme, however this proposal has not been pursued.

Type of data needed

There is a need to better understand the phenomenon to be able to subsequently mitigate against its impacts.

To have a basic understanding of the behaviour of jellyfish, baseline data is needed on distribution and typical abundances, as well as environmental oceanographic data. This data needs to be at both broad scale and high resolution. Following blooms in the Mediterranean, models were developed to predict the occurrence of blooms; however these lacked "at sea" data.

Data on jellyfish sightings needs to be widely available and accessible to all actors - decision makers, aquaculture production actors – and across geographies. Then it is important to understand the causes of blooms in order to think about strategies to

[53] http://cordis.europa.eu/projects/index.cfm?fuseaction=app.details&TXT=jellyfish&FRM=1&STP=10&SIC=&PGA=&CCY=&PCY=&SRC=&LNG=en&REF=64779

potentially prevent them. Finally, there is also a need for more information on a more sustainable approach to treating these blooms: so far, the choice has been for systematic destruction in order to avoid the nuisance.

Baxter *et al* have effectively summarized the research and data needs, arguing "widespread routine monitoring of jellyfish around aquaculture sites is necessary and will be fundamental if the links between their blooms and detrimental effects on the fish are to be fully understood. Widespread monitoring will be vital to obtain site-specific information jellyfish populations, including their seasonal occurrence and abundance. As yet, no reliable and cost effective mitigation methods exist to prevent small hydrozoan jellyfish from entering the cages (Rodger 2007, Hay & Murray 2008) and this should also be the focus of future studies". [54]

Marine knowledge 2020

Based on the directive EC 2008/56 (MSFD), European countries Member States shall establish and implement coordinated monitoring programmes for the ongoing assessment of the environmental status of their marine waters. Therefore, coordinated monitoring programmes of jellyfish blooms should be feasible to integrate into those programs. The data on jellyfish sightings is not integrated yet into the MSFD reporting database.

Because some studies have demonstrated that remote satellite observation is helpful in anticipating jellyfish blooms, the marine service of the European Earth monitoring programme (GMES/Copernicus) could be a strong tool in favour of developing a better understanding of jellyfish blooms and in developing an early warning system. Under the GMES/Copernicus programme, a marine service has been progressively developed and implemented by 60 organisations. This processes and analyses information from in-situ and space measurements to deliver two classes of information: (1) ocean observations and (2) monitoring and forecasting."

Innovative services and benefits

Current/ future services to be developed

With improved knowledge sharing and research, an early warning system could potentially be developed to address the following objectives:

- Anticipate the risk of jellyfish blooms : establish the movements and origin of jellyfish through the development of innovative tracking technologies
- Create eco-friendly response mechanisms for the jellyfish blooms, in order to channel them away from aquaculture production sites.

The innovative services could take the form of:

- A coordinated platform between all existing databases of jellyfish sightings that would help relay alerts to relevant observation centres
- A unified database of jellyfish sightings
- European-wide research programmes to address mitigating measures

So far projects seem to have been launched on a limited scale. Although there are many monitoring initiatives, these are at an early stage, and there is still a large amount of uncertainty regarding reasons for, and impacts of, jellyfish blooms. One limitation for monitoring was raised by the study in Scotland in 2010 - many blooms go unreported because aquaculture producers fear the insurance companies might set up a premium if

[54] Baxter, E., Rodger, H., McAllen, R., Doyle, T. (2011), "Gill disorders in marine-farmed salmon: investigating the role of hydrozoan jellyfish", Aquacult Environ Interact, Vol. 1: 245–257, 2011

their production is considered at risk.
Economic benefit
Hypothesis: A number of studies have attempted to quantify the impact of jellyfish blooms, both in Europe and elsewhere. In Irish and UK waters, the 2007 major fish kill (approximately 250 000 fish) by the mauve stinger wiped out Northern Ireland's only salmon farm, resulting in an economic loss of more than €1 million.[55] The Irish salmon aquaculture industry is worth € 60 million annually. A study[56] has revealed a 12% mortality rate due to gill disorders. It is believed that a key cause of this is through small jellyfish entering aquaculture cages and being inhaled by fish. On inhalation, they pass over the gills and inflict serious injuries. Using this logic, jellyfish blooms could represent a € 7.2 million annual lost to the salmon aquaculture industry. However, due to insufficient data, it is difficult to draw the link for certain between small jellyfish and the more common and chronic problem of gill disorders. In Peru, jellyfish display strong seasonal fluctuations, with peak abundances during summer. Off southern Peru and during the austral summer 2008–2009, C. plocamia were greater than 30% of the catch in 5% of the hauls, which was enough to cause economic losses of more than USD 200,000 in only 35 days of fishing.[57] In addition, a study in Korea[58] in 2012 estimated the damage cause to the Korean aquaculture production as between 2.1% and 25% of the annual production value, i.e. up to USD 204.6 million. **Extrapolation:** Due to limited information on the impact of jellyfish in Europe, we can only make a very gross approximation, since there have been jellyfish blooms in all sea basins across Europe. In 2009, the aquaculture production in the EU 27 was worth € 3.2 billion[59]. Assuming that jellyfish blooms affect mostly Mediterranean mussels, as well as northern rainbow trout and salmon production, this represents a € 1.4 billion market in 2009. If jellyfish are as damaging to the European production as they are to Korean production, the estimated cost could be from € 29 million (2.1% of 1.4) to € 345 million (25% of 1.4). Furthermore, taking a conservative approach and assuming that only half of the 12% mortality rate due to gill disorders could be attributed to jellyfish, and that the affected species are mostly Mediterranean mussels, as well as northern rainbow trout and salmon production (€1.4 billion market in 2009), **addressing jellyfish impacts would assist in avoiding losses to production of € 84 million** (1.4 billion x 6%).

Main data sources
Bastian, T., Stokes, D., Kelleher, J., Hays, G., Davenport, J., and Doyle, T. (2011), "Fisheries bycatch data provide insights into the distribution of the mauve stinger (Pelagia noctiluca) around Ireland", ICES Journal of Marine Science (2011), 68(3), 436–443. Baxter, E., Rodger, H., McAllen, R., Doyle, T. (2011), "Gill disorders in marine-farmed

55 Bastian, T., Stokes, D., Kelleher, J., Hays, G., Davenport, J., and Doyle, T. (2011), "Fisheries bycatch data provide insights into the distribution of the mauve stinger (Pelagia noctiluca) around Ireland", ICES Journal of Marine Science (2011), 68(3), 436–443.
56 Baxter, E., Rodger, H., McAllen, R., Doyle, T. (2011), "Gill disorders in marine-farmed salmon: investigating the role of hydrozoan jellyfish", Aquacult Environ Interact, Vol. 1: 245–257, 2011
57 Quinones, J., Monroy, A., Marcelo Acha, E., Mianzan, H. (2012), "Jellyfish bycatch diminishes profit in an anchovy fishery off Peru", Fish. Res. (2012)
58 Do-Hoon Kim, Ju-Nam Seo, Won-Duk Yoon, Young-Sang Suh, (2012), "Estimating the economic damage caused by jellyfish to fisheries in Korea", Fish Sci (2012) 78:1147–1152
59 Facts and Figures on the Common Fisheries Policy, 2012 edition, DG MARE

salmon: investigating the role of hydrozoan jellyfish", Aquacult Environ Interact, Vol. 1: 245–257, 2011

CIESM (Mediterranean Science Commission), CIESM JellyWatch Program http://www.ciesm.org/marine/programs/jellywatch.htm

Do-Hoon Kim, Ju-Nam Seo, Won-Duk Yoon, Young-Sang Suh, (2012), "Estimating the economic damage caused by jellyfish to fisheries in Korea", Fish Sci (2012) 78:1147–1152

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Quinones, J., Monroy, A., Marcelo Acha, E., Mianzan, H. (2012), "Jellyfish bycatch diminishes profit in an anchovy fishery off Peru", Fish. Res. (2012)

Stone, R. (2011), "Massive Outbreak of Jellyfish Could Spell Trouble for Fisheries", http://e360.yale.edu/feature/massive_outbreak_of_jellyfish_could_spell_trouble_for_fisheries/2359/?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed\%3A+YaleEnvironment360+\%28Yale+Environment+360

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Case 2: Offshore aquaculture: new sea-cage design

Case presentation: problem definition & opportunities
Overall context
Fish farms have traditionally been located in sheltered near-shore sites, with steel-framed rectangular support structures for the net cages, and walkways around them to serve as work platforms. However, in recent years, given both the growing demand for fish and the increasing awareness of potential spatial conflicts near-shore, opportunities for offshore aquaculture production have been increasingly investigated. However any development of offshore aquaculture will require a different design for cages. Cages in offshore sites have to withstand harsher weather conditions, they face a higher risk of invasive species and the mere distance from the shore implies more complex maintenance systems. Therefore, the aquaculture industry has identified the need for new sea-cage designs. Currently, the offshore fish cage design concepts are in their infancy and there is a race towards an optimum cage design for the offshore environment. An example of an industry moving offshore is the salmon farming industry, with the use of circular cages with plastic support structures but without a walkway. As a result, cages are dependent on boats for maintenance. The feeding of the fish, instead of being carried out by hand or by cannon/blower, is facilitated by automatic cage-mounted machines with a capacity of up to 100 square metres of feed. Visits by farm staff can thus be reduced, lowering staff costs. As salmon prices have dropped, these technology shifts, and a move towards a higher concentration of companies, are allowing the industry to cut operating costs and retain profitability.
Situation in Europe
Offshore aquaculture is still relatively new in Europe, with a few countries leading the way, such as Ireland and Spain. However offshore aquaculture, as a potential solution to address the fish production deficit and minimise marine spatial planning issues, can also present drawbacks. The following two examples illustrate the advantages and disadvantages of moving production offshore. › A disappointing Irish experience in moving mussel production offshore: the development of offshore aquaculture occurred due to the overcrowding of established bays and declining growth rates. Near-shore waters in Ireland are too shallow for finfish farming. But results in 2007 were disappointing for one main reason[60]: the failure of the equipment to withstand the harsh environment. Nonetheless, the "Deep sea fish farming project"[61], led by the Irish Sea Fisheries board, opted for conventional technology available, because the Galway bay is relatively sheltered, and therefore they should not face the same difficulties. › A promising offshore aquaculture project in the South of Spain[62]: an offshore aquaculture project was put in place in Spain between 2000 and 2007. The project was structured in three phases: › 1) testing technologies i.e. cage trials in exposed sites › 2) culture viability of new species › 3) transfer of technology to the aquaculture sector: the scientists reached a mutual agreement with a local fishermen's association, the "The Conil fish cop",

[60] International Offshore Aquaculture Workshop, 2007, Summary report
[61] http://www.bim.ie/our-work/case-studies/deepseafishfarminginireland/
[62] 'Experience in the South of Spain', Francisco Padilla, 2007 Presentation at Offshore Aquaculture workshop

who showed a great interest in becoming responsible for the project.

Although information is not conclusive on the success of the experiment, the conclusion is that off-shore cultivation in strong currents has as result a greater amount of flesh in the case of the molluscs and a less amount of fat in the fish: higher quality was related to higher currents.[63]

The need for marine knowledge in Europe

Current knowledge

Albeit the traditional approach to sea farming, there are a number of barriers to developing near-shore sites:

- maritime spatial planning issues
- the development of coastal tourism, of navigation and of other offshore installations
- public stakeholder acceptance and perception
- high environmental impact, due to waste disposal and eutrophication.

There is also potential uncertainty regarding water quality due to climate change. The increase in extreme weather events may affect aquaculture in several ways: physical destruction of aquaculture facilities, loss of stock and spread of disease. These risks are likely to be more severe in more open exposed sites.

Offshore aquaculture appears a potential method for further development, although there are challenges to overcome, one of which is cage design. There is a need to:

- Reduce manual maintenance requirements, as maintenance costs are higher the further away the cage is from the coast
- Automate feeding systems and caring of fish, for the same reasons as above (e.g. FP 5 research project SUBFEEDER-ATS, and FP4 research project "Cost effective and environmentally-friendly feed management strategies for Mediterranean cage aquaculture")
- Reduce the environmental impact of the cage production system.

Existing initiatives

There is research into determining the most efficient offshore cage that would reduce the cost of shallow water breeding and be resistant enough to withstand harsher and more uncertain weather events.

Significant advances in containment technologies have been made since the industry was developed, with modern production and fish transportation systems now typically large and highly mechanized. Initially, cage arrangements within sites were chosen based on logistical considerations such as moorings, shelter and accessibility. Present day cage approaches have moved towards positioning cage grid mooring systems perpendicular to the dominant current direction to maximise water flow, oxygen supply and the removal of waste from individual cages.[64] However, an industry specialist commented that these cages are not yet reliable enough for commercial purposes.[65]

To date, there are two different kinds of cages being developed:

- Surface cages

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[63] 'Experience in the South of Spain', Francisco Padilla, 2007 Presentation at Offshore Aquaculture Technology workshop
[64] Escapes of fish from Norwegian sea-cage aquaculture: causes, consequences, and methods to prevent escape, O. Jensen, T. Dempster, EB Thorstad, I. Uglem, A. Fredheim,
[65] Interview with Donal Maguire

- Submersible cages, considered more resistant to the waves and currents

A key research project undertaken under FP 6 programme was SUBFISHCAGE, which looked at developing of a cost effective submersible fish cage system. Similarly, the FP7 project FISHESCAPE looked at assessing the causes and developing measures to prevent the escape of fish from sea-cage aquaculture.

Ireland is considered a leader in offshore farming because Irish waters are too shallow for finfish cage farming, but there are many other countries, such as Spain and Norway, that have been exploring the possibilities of moving their production further offshore.

Other countries are investigating the opportunities, through research projects like the Offshore Aquaculture Technology Platform (OATP), which intends to develop organic salmon production in Ireland through offshore aquaculture to meet market demand and create jobs.

Type of data needed

Through an OATP evaluation on the future of offshore aquaculture in Europe, many points of concern were raised in relation to the feasibility of offshore aquaculture, which included:

- Safety issues and weather conditions (exposure)
- Environmental challenges and technology challenges associated with the exposed nature of the sites.
- Research & development requirements and technological demands

To summarise, the research gaps identified by the OATP evaluation concerning the development of new cages design can be classified in 3 different categories:

- Development of customised technology solutions across a range of areas specific to operating the harsh offshore environment.
- Introduction of systems and adoption of a systems analysis approach to solving husbandry and work practice issues in the context of offshore.
- The application of remote monitoring technology and telemetry to both site management and routine activities at offshore installations.

Cages and the associated nets and moorings were identified by stakeholders interviewed during the OATP evaluation as an area in need of particular development. Improvements are required both in terms of the ability of the structures to survive and function in the harsh offshore environment, as well as their suitability for incorporation in integrated systems for husbandry and farm management.

In order to develop the appropriate technology, there is a strong need for maritime data: **hydrographical and topographic data** to know where to install the cages, on the **structure and quality of the seabed, the quality and acidity of the water column, meteorological data** to predict waves, currents, information on past extreme weather events and **real time monitoring information.**

The **wave action (climate)** is indispensable in choosing the appropriate mooring site of the cage, but according to Perez et al[66], there is no single definite method to estimate the wave climate. Their paper on the case of Tenerife only estimates the wave height and disregards the wave period, which means it only takes into account half of the waves' characteristics.

To develop the suitability of offshore cages, there is a need for research on the **closing of life cycles** (to make sure most cultivated fish live through their whole life cycle and develop fully) as well as on the **functioning of the ecosystem**, in order to guarantee that aquaculture should not endanger stocks or biodiversity in general.

[66] On the calculation of wave climate for offshore cage culture site selection: a case study in Tenerife (Canary Islands), O.M. Perez, T.C. Telfer, L.G.Ross, 2003

Finally, there is a strong need for data on the **environmental impact of offshore aquaculture**; although moving offshore will possibly help mitigate many of the nutrient and bacterial contamination problems associated with inshore areas. But improved surveillance techniques are needed to prevent excess nutrients hitting the sea bed through wasted feed pellets.

Both specialists interviewed for this case study agree on the importance of **more accessible data** for the success of offshore aquaculture, since currently quality data can be expensive to obtain. There is a need for the dissemination of information to stakeholders, for research into effective media campaigns, development of real time monitoring reporting, aquaculture installations developed as suitable platforms for monitoring equipment.

As an example, in a case study comparing 3 cages design in Tenerife[67], Perez et al mention that none of the cage manufacturers provides a written specification of wave heights for which the cages are considered suitable. The little available information which manufacturers offer is generated from computer modelling, small scale laboratory tests or empirical data from specific operating sites.

Marine knowledge 2020

The Green paper on Marine Knowledge mentions that "without better accessibility to marine data, added-value services such as fish stock assessment or vulnerability of coastal infrastructure to storm surges can only be provided by the organisations holding the data. This is inefficient and anticompetitive. Opening up these resources allows new operators to enter the market. (..)

Interoperability allows small businesses or academics to develop new products and services based on data from different sources and of different types. The value of this to the EU economy is hard to estimate, but the impact assessment suggested it could be of the order of €200 million per year. The second specific objective of 'Marine Knowledge 2020' is to stimulate innovation.

That estimate does not take into account a rationalisation of present marine observation systems that would reduce uncertainty in our understanding of the behaviour of the sea. The economic value of this is even harder to guess, but could be even greater. Indeed, **uncertainty is a principal enemy of those responsible for designing offshore structures that can withstand the vagaries of the sea, for managing fish stocks or for designing protected marine areas. It has been estimated by 2120 that a 25% reduction in uncertainty in future sea-level rise would save public authorities responsible for coastal management approximately €100 million per year."**

Innovative services and benefits

Current/ future services to be developed

The objective is to develop a cage design that would allow aquaculture producers to develop their production in offshore sites while reducing both the costs of locating cages far from the shore and the risks linked to offshore operations. Types of products/services may include:

- New kinds of cages that would require less maintenance, limit escapes, and ensure

[67] On the calculation of wave climate for offshore cage culture site selection: a case study in Tenerife (Canary Islands), O.M. Perez, T.C. Telfer, L.G.Ross, 2003

the environmental impact of fish farming is minimal.

- Mobile cages: automated cages that would have a predictable trajectory or a controllable trajectory that could be filled with fingerlings in one point and then let loose for nine months until they reached their intended market with mature fish.[68]

Cages developed specifically for offshore aquaculture, rectangular and double cone, have been put into commercial use in recent years. In times of severe storms, the structures can be submerged below the high-energy surface waves.

Economic benefit

The economic benefit of this innovation is difficult to quantify as new cage designs impact aquaculture producers in potentially a number of manners, including:

- Lowering their production costs because they require fewer visits
- Lowering their production costs thanks to reduced uncertainty in the salinity and temperature of the water
- Lowering the risk of escape of fish - relatively little information exists on the direct costs of escapes, as reporting requirements differ from country to country, although the FP7 project Prevent Escape has sought to address this point (results are not yet publicly available). Nevertheless as an indication, in Norway, reported escapes of salmon on average account for losses of <0.2% of the fish held in sea-cages each year.

Three studies can help determine potential economic benefits of offshore aquaculture.

1. For the "Deep sea fish farming project" in Ireland, the Irish Sea Fisheries Board estimated that when in full production, the proposed fish farm should generate:

- Full time direct employment for approx. 350 people in rearing the juvenile fish, working on the farms and in processing and transporting the product to market.
- A further 150 jobs indirectly in providing netting, fish feed, transportation and other services to this farm.
- An annual wages flow of €14.5 million, much of which will find its way straight into the local economy in the vicinity of the farm.

In 2012 prices 15,000 tonnes of organic grade Irish salmon is worth €102 million to the market every year.[69] The majority of the fish produced will be for export markets. These estimates are based on data for other farms, such as Marine Harvest Ireland.

2. A study of the "Economic Feasibility and Impact of Offshore Aquaculture" in the Gulf of Mexico[70] concluded that a single farm operation directly employing only seven individuals for offshore production will provide an additional annual regional economic output (direct, indirect, and induced effects) of at least $US 9 million and provide additional employment for at least 262 persons, related to processing, feed production, distribution, etc.

3. Finally, reducing fish escape would be a strong economic benefit for the industry.

The escape of fish from sea-cage aquaculture is perceived both as a threat to wild fish populations and an economic burden. At the very heart of the escapes problem, lie technical and operational failures of fish farming equipment. Cages break down in storms, wear and tear of the netting causes holes, and operational accidents lead to spills of fish.

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[68] http://web.mit.edu/newsoffice/2008/aquaculture-0902.html
[69] http://www.bim.ie/our-work/case-studies/deepseafishfarminginireland/
[70] Posadas, B. C., and C. J. Bridger. 2005. Economic Feasibility and Impact of Offshore Aquaculture in the Gulf of Mexico. MASGP 04---. In Bridger, C. J. (ed.). Efforts to Develop a Responsible Offshore Aquaculture Industry in the Gulf of Mexico: A Compendium of Offshore Aquaculture Consortium Research. Mississippi-Alabama Sea Grant Consortium, Ocean Springs, MS

In Norway, where mandatory reporting of escape events is required of fish farmers, 3.93 million Atlantic salmon , 0.98 million rainbow trout and 1.05 million Atlantic cod were reported to have escaped over the 9 years from 2001-2009.[71] Though the figures seems insignificant with regards to the volume of fish produced (Approximately 310 million individual Atlantic salmon and rainbow trout were held in sea-cages in Norway at any given time during 2009), the industry is looking for ways to reduce the number of escapes.

Causes of escape vary between salmonids and Atlantic cod. Salmonids primarily escape after structural failures of containment equipment, while a far greater proportion of cod than salmon escape through holes in the net. The greatest cost of escape to the industry, however, is not replacing damaged infrastructures or insurance premiums: **escapes damage the industry's reputation.** The popular press often report escape events widely, which sheds negative light on the industry's environmental credentials and fuels criticism from environmental groups.

Data sources

Evaluation of the promotion of Offshore aquaculture through a Technology Platform, OATP, FP6-2005-SSP5A

Escapes of fish from Norwegian sea-cage aquaculture: causes, consequences, and methods to prevent escape, O. Jensen, T. Dempster, EB Thorstad, I. Uglem, A. Fredheim,

International Offshore Aquaculture Workshop, 2007, Summary report

Offshore Aquaculture Development in Ireland: Next Steps, Lucy Watson, Alan Drumm (Marine Institute)

On the calculation of wave climate for offshore cage culture site selection: a case study in Tenerife (Canary Islands), O.M. Perez, T.C. Telfer, L.G.Ross, 2003

Moving Aquaculture further offshore: Governance issues and challenges, FAO 1010

Recent Technological Innovations in Aquaculture, Rohana P. Subasinghe, David Curry, Sharon E. Mc Gladdery and Devin Bartley, 2003

The Bluewater Revolution, Charles Mann, 2004

http://www.foodandwaterwatch.org/fish/fish-farming/offshore/problems/

http://www.fusionmarine.com/news_immense%20potential_fish_farm.htm

http://www.oceanstewards.org/pdf/Cage-aquaculture-1.pdf

http://web.mit.edu/newsoffice/2008/aquaculture-0902.html

http://grist.org/food/the-big-blue-can-deep-water-fish-farming-be-sustainable/

Input received from:

Donal Maguire, Irish Sea Fisheries Board, in charge of "Deep Sea Fish Farming project" and Rosa Fernandez Otero, CETMAR, member of OATP

[71] Escapes of fish from Norwegian sea-cage aquaculture: causes, consequences, and methods to prevent escape, O. Jensen, T. Dempster, EB Thorstad, I. Uglem, A. Fredheim,

Case 3: Understand and address ocean acidification

Case presentation: problem definition & opportunities
Overall context
Ocean acidification is occurring because a part of the increased carbon dioxide humans are introducing into to the atmosphere dissolves in the ocean and reacts with water to produce an acid. Such large changes in ocean pH have probably not been experienced on the planet since such information has been collected. It is therefore not clear how ocean chemistry will change or how ecosystems will adapt. This phenomenon has strong impacts on the fauna and flora of the basins where it is observed, and therefore is a strong risk for aquaculture producers. For shellfish producers for instance, the results suggest that increased acidity is affecting the size and weight of shells and skeletons, and the trend is widespread across marine species. These animals are an important food source for marine predators such as tropical seabirds and seals as well as a valuable ingredient in human food production. Consequently, these changes are likely to affect humans and the ocean's large animals. The effort required by clams, sea snails and other shellfish to extract calcium carbonate from seawater to build their shells and skeletons varies across the world's oceans. A number of factors, including temperature and pressure, affect the availability of calcium carbonate for species that produce carbonate skeletons. This means that shellfish larvae have a much lower survival rate, because it takes the larvae much more time to build a shell. Therefore, there is a demonstrated economic impact of ocean acidification, as well as a long term environmental impact. In 2009, mollusc and crustacean production in Europe accounted for 50% of the total aquaculture production in volume. But since bivalve shellfish also act as natural water filter in their maturation phase, their decrease due to changing water quality has a long lasting environmental impact. The first areas to be impacted by ocean acidification are high-latitude regions and deep water areas, where the natural carbonate levels are lowest and closest to becoming undersaturated with respect to carbonate.

The need for marine knowledge in Europe
Current knowledge
Potential impact of ocean acidification on the structure of marine communities Studies have analysed the behaviour of shellfish in more acidic waters, in line with what is estimated to occur later in the century: clam and scallop larvae showed more than a 50% decline in survival. The larvae were also smaller and took longer to develop into the juvenile stage.[72] Shellfish larvae are free swimming. The more time they spend in the water column, the greater their risk of being eaten by a predator. A small change in the timing of the larval development could have a large effect on the number of larvae that survive to the juvenile stage and could dramatically alter the composition of the entire population. The studies also showed that oysters grew more slowly at this level of carbon dioxide, but their survival will only be diminished at carbon dioxide levels expected next century. With or without genetic change in relation to increased CO_2 at the species level, there is clearly also the possibility of changes in the relative abundance of species as CO_2 increases in the oceans. This is not an easy topic to address on the basis of available data from the oceans, because the effects are nonlinear and complex. Because ocean

[72] http://www.sciencedaily.com/releases/2009/10/091026162546.htm

acidification has only recently been recognised as a problem caused by climate change, impact studies and estimates of the economic impact are few in number. If this trend continues unabated, the ocean could become 150% more acidic by 2100 according to some estimates.[73] Chain reaction of increasing acidification Bivalve shellfish act as filter feeders: they feed on the rejects of other fish and the excess nutrient in the water, thus cleaning the surrounding waters and reducing the eutrophication of coastal waters. If they are not able to serve this function, this will have an increased impact on acidification. Important barriers to knowledge: not enough synergies in Europe Whilst there is a strong link between research and industry in the USA when it comes to the acidification of oceans, this is not yet the case across Europe. In the USA, there are examples where oyster farms have been relocated to Hawaii following acidification of waters off Washington State and Oregon.[74]
Existing initiatives
International interest has resulted in the launch of a few initiatives to develop synergies and create knowledge databases on ocean acidification and its impacts. The recently concluded FP7 funded project EPOCA (European Project on Ocean Acidification) focused on filling the numerous gaps in our understanding of the effects and implications of ocean acidification. It was essentially the first international research effort on ocean acidification. This was then followed by a number of recent FP7 projects such as PERMIAN-TRIASSIC CAS looking at investigating the effects of past global ocean acidification on marine ecosystems, and MEDSEA, the MEDiterranean Sea Acidification in a changing climate project. A new international centre, based at the International Atomic Energy Agency Environment Laboratories in Monaco, helps coordinate international research and link science and policy. To spur technological innovation in ocean health, the X-Prize foundation announced the Wendy Schmidt Ocean Health X-Prize, challenging entrepreneurs across the globe to 'replace today's expensive, cumbersome and slow pH monitoring systems' with new systems, portable and easily deployable in any conditions
Type of data needed
There is a strong need to understand ocean acidification, and the impact it has on shellfish in order to predict and minimise further negative impact on the different water basins. A number of studies regarding ocean acidification point to the same limitations and barriers to knowledge and understanding. They include: › There are not enough links between researchers and the industry › There is a global lack of comparability among experiments: insufficient description of the carbonate system parameters or other environmental conditions, different pH

[73] Healthy Ocean, Healthy people, Rio+20, UNESCO
[74] http://www.npr.org/blogs/thesalt/2012/08/01/157733954/how-climate-change-is-changing-the-oyster-business and http://seattletimes.com/html/localnews/2018496037_oysters22m.html

scales, etc.

- For paleo-studies, a significant limitation is the mismatch between paleo and modern ecosystems.[75]

Therefore, data needed is on :

- the quality of the water column,
- the behaviour of the fauna and flora to the changes in acidity,
- past events and impacts (comparable paleo-data).
- Real time monitoring data, such as the data Meteo France collects from its buoys, which would enable extreme events to be anticipated

Although existing quality datasets present strong evidence for the change in pH associated with the decrease in CO2, they are **few in number and represent limited geographic types**[76].

Large-scale programmes, such as the Geochemical Ocean Section Study (GEOSECS), the World Ocean Circulation Experiment (WOCE), and the US Joint Global Ocean Flux Study (JGOFS), have given precise and accurate descriptions of the global carbonate system, but only in series of snapshots, and these cannot be easily used to deduce the long-term trend from short-term variation. There is a need, therefore, for **more long-term series of these key parameters** in other areas.

As mentioned earlier, there is also a need for a better link between industry and research, to have an environment where results of research are freely available to aquaculture producers who wish to access it. Better coordination between industry and researchers could assist in research taking place at the production site, rather than under controlled conditions in a laboratory.[77]

Marine knowledge 2020

"Ocean acidification or changes in ocean salinity and dissolved oxygen will certainly have an impact on marine ecosystems and our ability to harvest from them. Earlier information will give industries such as that for shellfish aquaculture time to adapt."

"To support the development and dissemination of the knowledge base on adaptation, the Commission launched the European Climate Adaptation Platform, CLIMATEADAPT in March 2012, a publicly accessible internet site to support policy-makers in the development of climate change adaptation measures and policies at EU, national, regional and local levels. CLIMATE-ADAPT features a section on EU marine and fisheries policies, indicators of climate change and a database of adaptation case studies, in particular those from OUR COAST. The Commission is developing a proposal for an EU Adaptation Strategy, to be adopted in 2013.

A more structured approach to marine observations can deliver more accurate indicators of local changes in climatic parameters such as sea-level rise and ocean acidification to the CLIMATE-ADAPT platform and therefore help the adaptation process."

Innovative services and benefits

Current/ future services to be developed

The objective is to provide all stakeholders with an understanding of the causes and consequences of the actual acidification rate, in order for all stakeholders to find ways to

[75] http://www.ocean-acidification.net/Symposium2008/ResearchPrioritiesReport_OceanHighCO2WorldII.pdf
[76] http://biogeochemistry.org/biblio/Fernand_et_al_08_ICES_Report.pdf
[77] Interview with specialist

minimise the impacts. Types of products/services may include:

- A global observation network on ocean acidification, providing real time monitoring data on the state of the ocean and enabling aquaculture producers to better anticipate extreme events and take necessary measures to mitigate risk to production.
- An information platform for shellfish producers

There are many different research projects on ocean acidification :

- The UK Ocean Acidification Research Programme (UKOA)
- Biological Impacts of Ocean Acidification (BIOACID),
- European Project on Ocean Acidification (EPOCA),
- Mediterranean Sea Acidification in a changing climate (MedSeA)
- U.S. Ocean Carbon and Biogeochemistry Programme (OCB).

Economic benefit

Narita et al[78] have analysed the global mollusc production, and based on available data on the impact of acidification, they have estimated the economic costs of reduced mollusc production due to ocean acidification in 2100 under a business-as-usual scenario. in ten different basins, based on different scenarios: a constant demand of molluscs, an increasing demand of molluscs, income rises, no income rises, etc.

The global results are impressive: the estimation ranges from $US 6 billion to over $US 100 billion, although much of the volume is driven by the dominant Chinese basin. In the EU 15 (the membership of the EU at the time the study was undertaken), the total economic cost estimation is valued at $US 500 million (€ 375 million).[79]

This estimation of economic impact is only based on mollusc production. But because molluscs are the basis of many other fish feeding chains, the global impact of acidification in aquaculture (capture) should be even greater.

Tropical coral reef ecosystems, for example, provide food, income, and coastal protection for around 500 million people throughout tropical coastal areas of the world.[80] They have an estimated annual value of $US 30 billion with the protective function of reefs to shorelines valued at $US 9 billion per annum.[81] The global annual economic damage of ocean-acidification-induced coral reef loss by 2100 has been estimated to be $US 500 to $US 870 billion depending on the level of CO2 emissions scenarios.[82]

Therefore, the economic benefit of understanding and mitigating against ocean acidification, although hard to estimate precisely given the data available, would be highly significant, both in Europe and worldwide. If the scientific basis on the impact of acidification becomes more solid, research on the economic impact could be fed into a general equilibrium, to investigate the wider impact on trade, sectoral production and employment. Combined with an ecosystem model, such a study could help examine the broad impacts of ocean acidification on fisheries.

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[78] Economic Costs of Ocean Acidification: A Look into the Impacts on Shellfish Production, Daiju Narita, Katrin Rehdanz, Richard SJ Tol, 2011
[79] Aquaculture and capture molluscs, assuming income rise according to van Vuuren et al (2007)
[80] Hoegh-Guldberg O, Mumby PJ, Hooten AJ, Steneck RS, Greenfield P, Gomez E, Harvell CD, Sale PF, Edwards AJ, Caldeira K et al.: Coral reefs under rapid climate change and ocean acidification. Science 2007, 318:1737-1742.
[81] Cesar HSJ, Burke LM, Pet-Soede L: The economics of worldwide coral reef degradation. Cesar Environmental Economics Consulting (CEEC). 2003.
[82] Brander LM, Rehdanz K, Tol RSJ, van Beukering PJH: The economic impact of ocean acidification on coral reefs. ESRI Working Paper 2009, 282:1-33.

Data sources
Brander LM, Rehdanz K, Tol RSJ, van Beukering PJH: The economic impact of ocean acidification on coral reefs. ESRI Working Paper 2009, 282:1-33. Cesar HSJ, Burke LM, Pet-Soede L: The economics of worldwide coral reef degradation. Cesar Environmental Economics Consulting (CEEC). 2003. Changes in surface CO2 and ocean pH in ICES shelf sea ecosystems, ICES Cooperative Research Report, April 2008 Economic Costs of Ocean Acidification: A Look into the Impacts on Shellfish Production, Daiju Narita, Katrin Rehdanz, Richard SJ Tol, 2011 Hoegh-Guldberg O, Mumby PJ, Hooten AJ, Steneck RS, Greenfield P, Gomez E, Harvell CD, Sale PF, Edwards AJ, Caldeira K et al.: Coral reefs under rapid climate change and ocean acidification. Science 2007, 318:1737-1742. http://www.sciencedaily.com/releases/2012/08/120806085240.htm http://www.sciencedaily.com/releases/2009/10/091026162546.htm http://www.ocean-acidification.net/Symposium2008/ResearchPrioritiesReport_OceanHighCO2WorldII.pdf http://www.npr.org/blogs/thesalt/2012/08/01/157733954/how-climate-change-is-changing-the-oyster-business http://seattletimes.com/html/localnews/2018496037_oysters22m.html Zebra Mussel Farming in the Szczecin (Oder) Lagoon: Water-Quality Objectives and Cost-Effectiveness, Gerald Schernewski, Nardine Stybel and Thomas Neumann
Input received from: JP Gattuso, Laboratoire d'Océanographie de Villefrance-sur-mer, Observatoire Océanologique

6.5.2 Better assessment of risk by insurance companies

Case 4: Insurance products from better marine security information

Case presentation: problem definition & opportunities
Overall context
Commercial shipping relies on up-to-date nautical charts for one key reason – time is money. Reliable charts provide the most direct routes between ports, reduce the number of pilots required, decrease the number of groundings and reduce insurance rates. Maritime safety and insurance costs are inextricably linked. The structure of the global marketplace requires that goods and materials be delivered not only to the geographical location where they are required but also within a very precise timeframe. This can only happen if mariners are using up to date charts. The risks from poorly produced charts are significant. Accidents are not only undesirable outcomes in themselves; they also lead to the loss of lives. Lloyd's Register of Shipping estimates that between 1983 and 1992, 10,013 lives were lost either from collision or wreck resulted accidents.[83] A very good example of the attribution of poor charts to maritime accidents is the case of the Sea Diamond that sunk off the Aegean island of Santorini in April 2007.[84] In 2008, a year after the accident, the Cyprus-based Louis Cruise Lines blamed a faulty map for the grounding and subsequent sinking of Sea Diamond off Santorini, after commissioning a hydrographic survey by Greece's AKTI Engineering. The survey revealed that the reef the Sea Diamond hit - causing it to take on water and eventually sink - was both further from shore and larger than estimated on an official undersea map from the Hydrographic Office of the Hellenic Navy. A new hydrographic survey carried out by the Hydrographic Office of the Hellenic Navy - the official government authority for conducting hydrographic surveys in Greek waters and issuing nautical charts - confirmed the findings of AKTI. Insurers made a hull and machinery pay out $US 55 million.

The need for marine knowledge in Europe
Current knowledge
The reduction of accidents through the use of reliable charts and provision of maritime safety information could contribute to the lowering of insurance costs, which is a major operating cost factor for shipping companies. Anecdotal evidence suggests ships using waters with little hydrographic survey information have a high insurance premium related to the risk.[85] When transportation is subject to risk factors the cost of transportation and product is increased. For example, it has been argued that "with the exception of Algeria, Namibia, South Africa, and parts of Egypt, Morocco, Mozambique and Tunisia", most ports, port approaches and critical areas in Africa need hydrographic surveys to be undertaken and upgrading of the aids to navigation. Some projects have been started but generally the confidence of the international shipping in the information available is low. It has been reliably established that insurance charges on cargoes and vessels trading with Madagascar is 20% higher than the norm."[86]

[83] Alderton, P, (2004), Reeds Sea Transport: Operation And Economics, Fifth Edition, London
[84] Lloyd's list, http://www.lloydslist.com/ll/sector/cruise-and-ferry/article48685.ece
[85] Interview comment : Bryant, 2009
[86] Guy, N. (2006) "Capacity Building for Countries in Transition", Proceedings of the 25th Southern African Transport Conference (SATC)

Existing initiatives
The International Hydrographic Organization produces a survey to identify the data gaps in hydrographic data. They have highlighted their concerns over large areas of unsurveyed waters which are delineated on charts of the Persian Gulf, as well as on the S side of the Sicilian channel.
Type of data needed
Perceived benefits of economies of scale has led to bigger and bigger ships, with Maersk's contract with Daewoo Shipbuilding for twenty 18,000 TEU container ships just one example. **Structural integrity of untested designs is a serious concern** to insurers and the hull and cargo claims that would follow the failure of one of these huge ships would be enormous. Therefore, insurance and reinsurance companies are looking for ways that would help them estimate the risk accurately and adapt their prices accordingly. Therefore, in order for insurance companies to build accurate models, there is a strong need for: › reliable nautical charts : hydrographic and bathymetric data is indispensable, especially with a growing trend for ships with large drafts › meteorological data in order to prevent natural events (storms, floods, etc..) and be able to protect both hull and cargo Though some data is already available, more data is needed for an accurate assessment of risks: for instance, for bathymetry, precise punctual data is available, however, it is too sparse to assess the seafloor morphology and slope. There is a need for a high resolution DTM (MBES survey), possibly completed by a description of conspicuous, punctual topographic irregularities (wrecks, submerged rocks, obstructions).[87]
Marine knowledge 2020
One of the central goals of Marine 2020 is the reduction of uncertainty concerning knowledge of the oceans and seas so as to provide a sounder scientific basis for decision making, including the appraisal and reduction of risk. Marine Knowledge 2020 has the potential to play a crucial role in unlocking the vast amounts of relevant marine data that exist in the private and public sphere, but are currently difficult to access for public and private researchers alike.

Innovative services and benefits
Current/ future services to be developed
Through more reliable data in terms of nautical charts and maritime safety information, Insurance providers may be willing to offer products with reduced premium's resulting in lower insurance costs, which is a major operating cost factor for shipping companies.
Economic benefit

[87] SHOM, "Marine environment monitoring :The basic requirements to support Marine Renewable Energies", presentation, 2012

The marine insurance industry is a relatively small (representing less than 2% of non-life premiums)[88], but highly developed in core business areas. Nonetheless, marine insurance premiums are known for their volatility, with a complex array of internal and external drivers acting. However, improved navigational technology, owing, in large part, to greater availability of marine data of all types, has significantly reduced the risk associated with this industry, facilitating the tremendous expansion of ocean trade that is the backbone of the world economy. In 2008, the UK marine insurance market alone, one of the largest in the world, represented £ 3.7 billion[89]. If increased marine data can help underwriters better assess risks and reduce premium by just 1%, it would represent an annual savings of € 37 million for annually for owners/operators insured in the UK market.

Because of the complexity of making assumptions on such a large scale, the following anecdotal examples illustrate in a more concrete manner the economic benefits in terms of reducing risk, and therefore cost, from the use of better data:

USA company MICAD Marine LLC manufactures computer hardware and software, with its flagship product being the MICAD Marine System, a real-time marine data collection and management system which, in addition to information and diagnostics, includes satellite communication, vessel and fuel management, and permanent archival of vessel data on each individual vessel or an entire fleet of vessels.

In 2005, MICAD Marine and the PIMSIC Group, an international established insurance firm, announced a new agreement to provide deeply discounted insurance products to MICAD Marine customers worldwide.

Recognising the greatly increased safety, security and accountability of vessels equipped with the MICAD Marine System, PIMSIC Group made a decision to offer MICAD customers up to 20% off their current insurance costs, including protection and indemnity, protection of marine hull, machinery and cargo, and crew liability and personal accident.[90]

While not insurance related, another example of financial incentives given to promote the adoption of advanced, safer navigational systems is the reduction offered by Canadian authorities on the Marine Navigation Services Fee (MNSF). For over 15 years, the Canadian Department of Fisheries and Oceans has provided a 5% reduction for all ships subject to the fee that were operating with a Precision Navigation System (PNS) on board According to the Canadian Coast Guard, the incentive serves as a recognition of the significant safety and efficiency benefits of PNS.[91] According to Canadian authorities, a PNS comprises two essential components, an Electronic Chart Display and Information System and a Differential Global Positioning System (DGPS) which is used for terrestrial long range navigation by using transmitted corrections. Cost savings to ship owners would range from just CAD $ 10 for small vessels under 15 gross tons to over CAD $ 300 for a ship weighing in at 1,500 gross tons.[92]

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88 'Marine Insurance' Astrid Seltmann Encyclopedia of Actuarial Science, 2006
89 'UK Marine Insurance Brief', October 2009, IRN Research
90 MJ Information, (2005), "Be Safe, Save Money at Seawork", http://www.maritimejournal.com/comment-and analysis101/be_safe,_save_money_at_seawork
91 http://www.ccg-gcc.gc.ca/eng/Ccg/ice_Pns
92 http://www.ccg-gcc.gc.ca/eng/Ccg/Ice_Fees_To_Canadian_Vessels

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Alderton, P, (2004), Reeds Sea Transport: Operation And Economics, Fifth Edition, London Guy, N. (2006) "Capacity Building for Countries in Transition", Proceedings of the 25th Southern African Transport Conference (SATC) Lloyd's list, http://www.lloydslist.com/ll/sector/cruise-and-ferry/article48685.ece MJ Information, (2005), "Be Safe, Save Money at Seawork", http://www.maritimejournal.com/comment-and analysis101/be_safe,_save_money_at_seawork Marine market review, April 2012, Willis
Note on inputs: Several large international insurers were contacted to comment on this example, but were not available to provide comment

Case 5: Managing Natural Disaster Risk in Europe's Coastal Regions

Case presentation: problem definition & opportunities
Overall context
Unforeseen evolutions in the nature, scale or location of disasters are among the most important threats to the insurance system today.[93] Climate change, in particular, has the potential to have highly adverse impacts on insurance affordability and availability. Climate change refers to a number of evolutions in the world's weather patterns, but has been particularly associated with higher incidence of weather-related natural disasters, including storms, flooding, wind and episodes of extreme heat or cold. Europe's coastal regions in particular could be highly affected. It is widely recognized within the scientific community and, increasingly, in the insurance industry, that the costs of weather-related natural disasters have been rising and in large part due to climate change. The impacts of these changes include an increased need for assistance from outside of the impacted areas (aid from the international donor community in the developing world and public assistance in the developed world) and a shrinking margin between insurance premiums and losses. While the migration of people to flood prone areas along the coast, increasing reliance on vulnerable infrastructure (especially power grids), and the overall rising material wealth of society have played a role in the increasing costliness of natural disasters, global weather-related losses in recent years have been *trending upward much faster than population, inflation, or insurance penetration, and faster than non–weather-related events* and this despite improved building codes, early warning systems, flood control, disaster preparedness and response[94]. Climate has the potential to impact most forms of insurance, including property, liability, health, and life, on a large scale. For instance, a report published in 2009 by the Association of British Insurers reckoned that inland flood component of insurance premiums could increase by around 21% across Great Britain if a global temperature rise of four degrees centigrade is assumed.[95] If insufficiently addressed in terms of industry strategy, preparedness and though tackling the issue itself, it could potentially slow the growth of the industry and shift more of the burden to governments and consumers. As the insurability of highly affected regions declines, particularly coastal regions, insurers may have to use traditional methods to reduce their exposures, including increased premiums and deductibles, lowered limits, nonrenewals, and new exclusions, pushing the burden onto consumers and government and immobilizing increasing amounts of global capital. It is increasingly important that insurers, industry regulators, and the wider policy community develop a better understanding of the risks posed by climate change and the increased migration of people to disaster prone areas. The insurance industry itself is well positioned to monitor disaster loss trends, improve the sophistication of catastrophe modeling, finding new and innovative risk transfer solutions, adapt strategy and use their weight to address the causes of climate change on the political agenda. Data will play a fundamental role in this process, in particular by **allowing industry researchers to better understand these evolutions**. Beyond merely understanding climate change, monitoring data will be essential to better **assessing the effects of this change and, consequently, how to better reduce, mitigate and share risk**. There is already a wealth data being produced by public and private actors, as well as a number of research initiatives, however, this data is highly fragmented and of little use for climatologists and actuaries seeking to better understand and plan for the effects of climate change. There is a need to improve our knowledge of the benefits of climate policy, as a

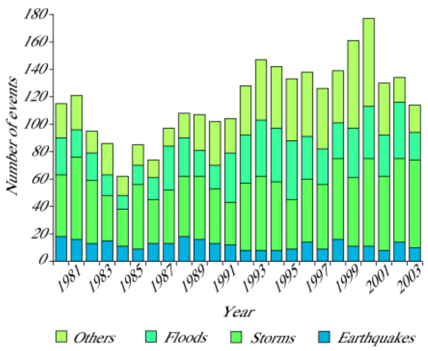
[93] 'Insurance in a Climate of Change'
[94] 'Insurance in a Climate of Change'
[95] 'Assessing the Risk of Climate Change: Financial Implications'

comprehensive, systematic and consistent assessment of the monetized damage of climate change in the various sectors in Europe is not yet available.

Situation in Europe

Compared with the developing world (particularly Asia and Oceania) and certain parts of the developed world such as the United States, the medium term impacts of climate change will be less challenging in Europe. Natural catastrophes and manmade disasters caused economic losses of around $US 9 billion in Europe (around 2.5% of total global loss totalling over 370 billion) and took the lives of over 1 000 people in 2011[96]. The number of natural catastrophes has been slowly rising, although the cost has increased more sharply relative to the overall number[97]. However, many experts consider the incidence of natural catastrophes to continue to rise in Europe. The last decade (2002–2011) was the warmest on record, with European land temperature 1.3 degrees centigrade warmer than the pre-industrial average. Various model projections show that Europe could become 2.5 to 4 degrees centigrade warmer in the late 21st Century[98]. The European Environmental Agency has identified some of most important likely impacts of climate change in Europe including, increased precipitation (Northern Europe), heat waves, droughts, river flooding, river flow droughts, rising sea levels, coastal flooding and erosion, as well as changes in plant and animal characteristics that could impact agriculture and fisheries.

Figure 5: Natural catastrophes in Europe 1981 – 2003 (number)



Source: European Environmental Agency

<u>Europe's coastal areas</u>

The projected climate change effects that will impact for coastal areas include, *inter alia*, sea-level rise, changes in temperature, the direction and the power of waves, wind, precipitation and ice-cover, as well as an increase in extreme weather events. The European Environmental Agency also points to the potentially devastating effects of increased coastal flooding and erosion, saline intrusion, freshwater shortage and the loss of coastal ecosystems. A 2009 report on 'The Economies of Climate Change Adaptation in EU Coastal Areas' reported that the annual global adaptation cost to protect against coastal flooding due to sea-level rise lies somewhere between $US 5 billion and $US 15 billion, and about € 0.5 to € 0.85 billion a year for Europe.

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96 'Sigma Report : Natural Catastrophes and Man-made Disasters in 2011'
97 'Sigma Report : Natural Catastrophes and Man-made Disasters in 2011'
98 European Environmental Agency

The need for marine knowledge in Europe
Current knowledge
Both public and private actors, as well as numerous research initiatives produce a large amount of marine data that could be potentially useful to researchers and insurance companies in understanding the impacts of climate change for Europe's coastal communities. The European insurance and reinsurance industry has also taken a relatively proactive approach to understanding the ramifications of climate change, as well as broader demographic and economic trends that affect the level of economic lost in natural disaster situations. The insurance industry is a key player in the development of knowledge and collection and exploitation of data in this domain. Large reinsurance companies such as Munich Re and Swiss Re and insurance associations such as the Association of British Insurers) collect and regularly publish economic data on natural disasters or loss events. On an annual basis, they typically publish information regarding total economic losses and total insured losses per type of weather event (storms, floods, droughts) and aggregate them at different levels. Insurance companies with a stake in weather-related risks are also increasingly turning to climatologists. Like actuaries, climatologists rely heavily on statistics for the development of weather-related catastrophe models that combine the tools of both professions and help better assess risk and understand trends. For example, in the 1990s, a group of insurance companies launched the 'Risk Prediction Initiative' in Bermuda in order to review the foundations of climate science, hurricane risks, El Niño, and climate change and many large insurance companies and industry associations have invested in risk management and sustainability units that look at the effects of climate change in addition to other emerging risks, such as Swiss Re's Sustainability & Emerging Risk Management unit. Metocean data collection is collected on a widespread basis in Europe, for private and public needs. It is the collection of meteorological and oceanographic data, including: offshore meteorological conditions (wind, sea level pressure…) and sea states and water movements (tidal elevations and current flows…).[99] For the private sector, the collection of reliable, quality metocean data is essential for the success of various marine projects, such as offshore installations, shipping, etc. Daily as *well* as extreme conditions must be taken into account in the design, cost and profitability assessment and placement of offshore wind/wave energy installations and oil platforms, for examples, and marine operations rely heavily on metocean data on a daily basis for predicting safe 'weather windows'. Public authorities also extensively collect metocean data as a public service or for specific purposes.
Existing initiatives
Many initiatives currently exist in the public and private sector and scientific community in Europe, to improve the provision of metocean data. While the American industry response to increasingly severe weather patterns has been conservative, lobbying the government to establish ever larger safety nets for the industry (although the American industry is beginning to recognise climate change challenges), their European counterparts have shown themselves to be much more proactive from the 1990s. There are many exciting examples of new and innovative research that is being carried out within the insurance industry itself. Companies are even beginning to try and articulate how this can be integrated into core business activity and strategy. For example, in 2007, ClimateWise, the global insurance industry's leadership group to drive action on climate change risk, established a set of principles against which members would be annually reviewed. Principle one calls on the industry to become a 'leader in risk' and lays out an ambitious agenda for developing innovative risk analysis,

[99] UK Renewable

including the improvement data quality to inform levels of pricing, capital and reserves to match changing risks. ClimateWise has brought industry together for joint-research initiatives, such as their 2012 report on Carbon Capture[100] and provides impetus to the industry, particularly in the domain of better understanding risk. For instance, Zurich has created a globally-managed Catastrophe function[101]. This function consists of specialised teams dedicated to catastrophe modeling, underwriting, pricing and reporting, as well as research & development. Building on innovative geophysical, seismological and meteorological research, the goal of this function is to better quantify (re)insurance risk to catastrophe.

European financed initiatives are also seeking to improve the **collection and dissemination** of comprehensive metocean data in order to better **understand and mitigate** against climate change in Europe's coastal regions:

SeaDataNet, financed by the EU, offers a pan-European **infrastructure for managing and accessing marine and ocean data** by connecting National Oceanographic Data Centres (NODC's) and oceanographic data focal points from 35 coastal states in Europe. The portal also provides overviews of marine organisations in Europe and their engagement in research, scientific cruises, monitoring and data management for European waters and global oceans and works towards the establishment of common standards (vocabularies, metadata formats, transport formats…).

The Technical University of Delft in the Netherlands has secured nearly € 3 million of European funding for **nearshore monitoring and modelling of coastal behaviour**, in order to help develop a more informed coastal management strategies and mitigate adverse impacts of coastal change. State-of-the-art field monitoring methods will be deployed over a five year period along a 20 kilometre stretch of coast. The monitoring equipment will allow researcher to acquire unprecedented process information at different temporal and spatial scales.

The French Institute Marine Research and Exploitation (IFREMER) is currently leading JERICO, an ambitious project building a **Pan European network for European coastal marine observatory**. This network will integrating infrastructure and technologies such as moorings, drifters, ferrybox and gliders from different national observatories. The project hopes to lead to the definition of best practices for design, implementation, maintenance and distribution of data of coastal observing systems, as well as the definition of a quality standard.

The ADAM project (2006 – 2009), financed under FP6, brought together some 120 researchers from 26 research institutions across Europe, as well as internationally, in order to support the development of post-2012 global climate policies, the definition of European mitigation policies to reach its 2020 goals, and the **emergence of new adaptation policies for Europe with special attention to the role of extreme weather events**. In particular, one of the three principal objectives was to develop the requirements for climate change appraisal in different contexts to enhance the emergence of innovative mitigation and adaptation strategies.

The MICORE project (2009 – 2011) contributed to the **development of a probabilistic mapping of the morphological impact of marine storms** and to the production of early warning and information systems to support long-term disaster reduction. Within the framework of the project, a review of historical storms that had a significant impact on a representative number of sensitive European sites will be undertaken. Data was compiled into in a homogeneous database of occurrence and related socio-economic damages, including the following information on the characteristics of the storms, on their morphological impacts, on the damages caused on society, on the Civil Protection schemes implemented after the events.

Type of data needed

The type of data needed can vary significantly depending on the type of analysis, what

[100] Managing Liabilities of European Carbon Capture and Storage
[101] ClimateWise Report 2012

type of disasters are likely to occur in particular areas and on what level analysis is being situated, from local monitoring activities in flood prone areas that relies on indicators such as rain-fall data, water level telemetry stream flow and storm surge to climate change modelling that needs reliable time-series data on a whole span of climatological indicators. The more widely available and more refined the data is, the fewer assumptions that must be made in mode and the more reliable the model is. Although relatively of less importance in many part of Europe, cross-cutting analysis for disaster preparedness and mitigation often also draws on human development indicators such as the geospatial distribution of poverty and access to basic sanitation, in order to better understand risk. The table below illustrates the range of activities linked with better understanding, preparing for and mitigating the effects of climate change that could benefit from greater availability of marine data (among many other types of data).

Understanding risk	Risk Reduction	Risk mitigation
• Climate change modelling • Hazard zoning • Vulnerability and societal impact mapping	• Early warning systems • Infrastructural investment • Public awareness, building codes	• Development of mitigation plans • Development of alternative risk transfer schemes

Public data sets relevant to climate change and natural disaster occurrence can often be obtained through public authorities, although this not systematic and data is often stored in different formats. In the private sector, vast amounts of detailed data are amassed, often at a substantial cost in remote areas. However, much of this data is stored away after use and inaccessible to the research community. Some industry initiatives have tried to address this issue. For example, in order to stimulate and support a wider application of industry metocean datasets, a System of Industry Metocean data for the Offshore and Research Communities (SIMORC) was established. This service aims at improving awareness of available data sets and has established a systematic indexing and archival of these data sets within the industry. The initiative hopes to improve reporting and access to these data sets and the results of field studies among the scientific community.

Marine knowledge 2020

One of the central tenants of Marine 2020 is to reduce uncertainty in knowledge of the oceans and seas so as to provide a sounder scientific basis for managing future changes. Marine Knowledge 2020 has the potential to play a crucial role in opening up the vast amounts of metocean data that exist in the private and public sphere, but are currently difficult to access. This data can help researchers and the insurance industry better assess developing risks stemming from climate change and adopt innovative methods for sustainably dealing with these changes. Specifically, Marine Knowledge can ensure that data generated from European funded projects is available for use, in standardised formats and easy to access. Data sharing between the private sector actors, such a big oil and gas companies which generate substantial amounts of data exhaust, and the research community can also be facilitated by Marine Knowledge. Finally, data sharing on the part of public authorities can be encouraged and European wide, standards established.

Innovative services and benefits
Current/ future services to be developed
Better understanding of the risks of climate change has the potential to spur action across the industry and could prompt the deployment of many innovative services and strategies (risk sharing). Furthermore, data will be essential to the formulation of more effective risk mitigation strategies (risk reduction). Encouraging risk management through policies Insurers have traditionally played an important role in changing behaviours and raising awareness. The industry can develop policies that reward policy holders for being proactive in protecting themselves against climate change risk. In this way, the industry can influence building codes, land use, infrastructure design and help ensure resiliency on the ground in high risk communities. Furthermore, more comprehensive disaster risk assessments that allow policy makers to understand how the environment is changing and where investment is needed to mitigate those changes can make coastal adaptation investments and other mitigating activities more cost-effective. Public-private cooperation on managing risk The Association of British Insurers and the UK government have agreed to ensure that flood insurance remains widely available and affordable, but also sustainably in the long-term. The government has offered to develop a long-term investment strategy defining flood prevention objectives and assessing policy options and funding needs. In return, insurers have agreed to make flood insurance for homes and small businesses available where the flood-risk has a maximum return period of 1:75. In case flood-risk is more significant, coverage will be offered whenever there are plans available to reduce the risk to an acceptable level within a period of 5 years.
Economic benefit
The economic benefits of improved risk assessment are relatively diffuse, although substantial in the long run. With losses in 2011 in Europe totalling over $US 9 billion, it is not a stretch to imagine that strategic investments in adapting Europe's coastal regions could result in hundreds of millions in economic benefit. For instance, if better modelling and monitoring allowed coastal adaptations to be only slightly more effective, losses could be reduced by millions annually. While this estimate is crude and doesn't take into account more unquantifiable benefits such as the long-term health of Europe's insurance industry, it gives an idea of how small investments can make a huge impact. On a general level, considerable economic gain can be secured by understanding risks as they develop and not after they have already inflicted their damage. In this sense, understanding climate change is about making cost-effective investments and adopting sustainable strategies. The insurance industry will have to understand how these and other changes will impact their bottom line and integrate innovative approaches to ensuring sustainability, while public actors need to make important investments to adapt Europe's coasts to new risks and work with the insurance industry to ensure the availability and affordability of insurance. Inform public policy making A clearer idea of the effects of climate change as well as a more precise estimate of the economic impact of these changes can help improve the policy making process by internalizing the economic impact of climate change into the decision-making equation. Unquantified costs, although real, are often ambiguous and not fully taken into consideration, or even worse, ignored in the policymaking process. Developing hard, quantified knowledge of the likely future effects of climate change can thus lead to more informed, scientifically based policy decisions. Support climate awareness amongst customers Insurers have the potential to play a proactive role in changing behaviour and mobilising public opinion. Because they have so much at stake, the insurance industry has historically been influential in motivating society to reduce risks, whether by advocating for smoke detectors in buildings or safety restraints in vehicles. While, insurers must

ensure that rates and loss reserves adequately cover potential costs stemming from higher frequency and severity of catastrophic events, they can develop preferential pricing policies to property owners who have increased the resiliency of their structures. This can spur public and private action to address the root causes of climate change and invest in risk mitigation (disaster preparedness etc).

Incorporate climate change into business strategies

The insurance industry must be able to accurately assess and, where possible price the risks associated with climate change and incorporate them into their business strategies. To do this, it is imperative to invest in research that enables them to make informed strategic decisions. Without foresighted action, the insurance company will have increasing difficulty absorbing the cost of the increased incidence of natural disaster, leading to suboptimal outcomes. While in the short-term more accurate pricing may raise premiums in some disaster prone areas, it is an important mechanism in helping society sustainably evolve and manage future risk and, in the long-run, a sound insurance industry is of fundamental importance to the functioning and growth of the economy.

Data sources

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ClimateWise (2012) Managing Liabilities of European Carbon Capture and Storage

Case 6: Improving the certification process for offshore wind projects

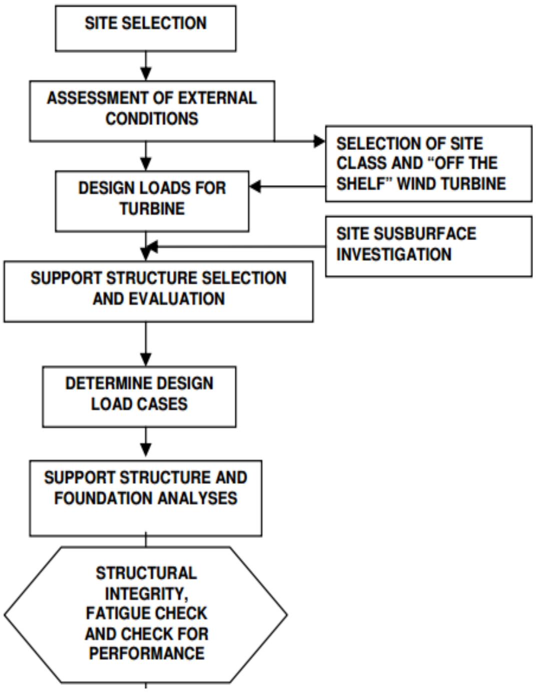
Case presentation: problem definition & opportunities
Overall context
The offshore wind sector is highly dynamic and characterised by quickly evolving technologies. As turbines become larger and larger and the location of wind farms moves further offshore, designers are adopting innovative new technologies that are more cost-effective and better able to stand up to the unique challenges of offshore wind. Larger, more technologically advanced turbines further offshore means the consequences of mistakes and failures becomes larger and more expensive and more effectively managing risk becomes imperative for investors and developers While the quick pace of innovation and change in the sector is one of its strengths, it also makes it hard to assess risk as innovative designs are continually deployed on a larger and larger scale. This can result in both high insurance premiums for project investors and/or suboptimal risk mitigation if underwriters are uncomfortable, for example, extending policy coverage in the area of defective design or serial loss. Furthermore, assessing remaining useful life, which is essential for understanding risk over the long term, can be difficult with the lack of proven designs with long track records. Remaining useful life is a technical jargon for understanding how assets will deteriorate over the years. It helps to have a better idea of risk over the long-term and to more cost-effectively manage the deterioration process and reduce the likelihood of a sudden equipment failure. To protect investments and maximise potential profits, owners, investors and insurance companies are increasingly looking to experienced third-parties to verify that the wind farms will perform successfully and to help better manage natural deterioration. In some countries, project certification is an obligation of national agencies for offshore wind installations, although, even when not required by regulation, most project managers pursue project certification and post-installation services in order to gain additional assurance for their offshore wind project and the design of the turbine itself. According to Lloyd's Register, the certification process is intended to give independent assurance that the wind farm construction and operation is executed in a manner that meets all relevant technical and safety standards and offshore industry best practice . The offshore wind insurance industry is relatively immature and, with constantly evolving technologies, insurers are hesitant to extend certain types of coverage, particularly to post-warranty operations. With little proven track record for these technologies, certification bodies play a particularly important role in ensuring the soundness and long-term viability. Marine data plays a fundamental role in the certification and life-cycle management services offered by third parties, which help bridge the divide between a quickly evolving sector and the insurance industry. The site condition evaluation is the first step of the certification process and the basis for the design basis evaluation, provides the parameters for the facility loading analysis and eventually will feed into the project specific maintenance strategy. Site assessment involves costly data collection on the part of the private sector and will typically be restricted to basic wind, wave, soil and current data for the site, using theoretical methods to account for data that is not available. Increased amounts of marine data have the potential to help improve the testing of new offshore wind technologies, as well as the understanding of the long-term performance of new technologies in the offshore wind sector, encouraging insurers to extend coverage and lower premiums. While publicly available data isn't typically 'high resolution' enough to replace site specific data collection, it has the potential to be highly valuable in this process, particularly at the conceptual design stage.
Situation in Europe
The large potential of offshore wind has only recently been recognized within the wind industry. While offshore wind farms are much more expensive, with larger turbines, costly foundation structures and higher operation costs, they can also generate 20% more energy than onshore installations. The European Wind Energy Association has called offshore wind, Europe's largest indigenous energy resource, with EEA estimates of the technical potential of offshore wind in 2020 at 25,000 TWh, between six and seven times greater than projected electricity demand, and rising to 30,000 TWh in 2030,

seven times greater than projected electricity demand[102].

Because of this huge potential and the increasing technical and economic feasibility of offshore farms, Europe has made major investments in offshore wind in North West Europe, in particular Denmark and the UK. Offshore wind is expected to make important contributions to the EU's Energy Policy objectives. According to figures from the European Wind Association, in June 2011, 4.3 GW installed, representing approximately 10% of Europe's wind energy installations. A total of 40 GW installed capacity is expected by 2020, or roughly 4% of EU electricity demand and 150 GW by 2030, meeting an estimated 14% of EU electricity demand. The expansion of offshore wind energy is creating significant economic activity, employing 35 000 people in 2011 and representing € 2.8 billion in investment. Today, offshore wind farms are typically 50-150 MW of installed capacity being sited up to 20 km offshore in water depths of up to 20 m and using wind turbines with 2-3 MW capacity. However, to keep pace with the predicted levels of deployment over the next 20 years, offshore wind farms are expected to involve 500-1000 MW of installed capacity comprising 3-5 MW wind turbines and be sited 20 to over 100 km offshore in water depths of 20-40 m[103].

The need for marine knowledge in Europe

Current knowledge



Certification can concern the turbine itself (quality assurance, design assessment and prototype testing), the turbine site and ultimately a 'project certificate', after which, many third parties offer life cycle management services. It allows for the identification of problems upstream and assists developers and owners in better understanding the integrity of their assets, allowing for more effective inspection and maintenance programmes. For a project or design to receive certification, it will generally have to be subjected to various tests, such as load simulations and field trials. With experience, the certification process has become increasingly refined and has become codified in international standards for wind energy certification, IEC 61400-22 and other standards in the IEC 61400 series and cover design, build and operational requirements.

Certification normally begins with a site assessment. The purpose of evaluating the site conditions is to check whether the environmental conditions, electrical connections and soil parameters defined in the design documentation are appropriate for the wind farm location. Site condition data collection will typically consist of key environmental parameters, such as wind, wave, current and water-surface elevation conditions, snow,

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[102] 'Oceans of Opportunity : Harnessing Europe's larges domestic energy source'. European Wind Association 2009.
[103] http://www.euinfrastructure.com/article/Offshore-wind-farms--managing-risks-through-project-certification/

ice and temperature conditions, geotechnical and geophysical conditions, earthquake conditions, electrical power network conditions, weather windows and weather downtime, as well as seabed characteristics important to the turbine's foundation. Loading analysis defines the site-specific loads and load effects on the wind turbine and supporting structure foundations and rotor nacelle assembly (wind loading for the turbine structure, wave and current loading on the support structure, as well as other variable and environmental loads). The loading conditions report should then demonstrate that the loading calculations comply with the design basis, confirming whether or not a type approved design is suitable for specific design conditions and/or is suitable to a specific site. The analysis is designed to demonstrate the structural integrity of components in the context of the chosen site and better understand how the infrastructure will age (lifespan of key components) in order to develop more effective operating and maintenance strategies. After the testing and certification of the design and site, independent certifiers also offer 'life-cycle management' services, which help operators better manage their assets over the long-run, getting the most out of their investment and extending the life of the infrastructure.
Existing Initiatives
Data collection in the offshore industry for the development of new sites is typically done privately and is limited to key data needed for assessing the suitability of the site and testing the design. Collecting data can be costly, as a number of factors have to be considered and the measurement period must be sufficiently long to obtain reliable data that takes into account seasonal variations. Site data is then collected, such as, wind, wave, current and water-surface elevation conditions, snow, ice and temperature conditions, geotechnical and geophysical conditions, earthquake conditions, electrical power network conditions, weather windows and weather downtime, as well as seabed characteristics important to the turbine's foundation. A very broad range of metocean data collection is collected in Europe, for private and public needs. For the private sector, the collection of reliable, quality metocean data is essential for the success of various marine projects, such as offshore installations, shipping, etc. Daily as well as extreme conditions must be taken into account in the design, cost and profitability assessment and placement of offshore wind/wave energy installations and oil platforms, for examples, and marine operations rely heavily on metocean data on a daily basis for predicting safe 'weather windows'. Public authorities also extensively collect metocean data as a public service or for specific purposes. Furthermore, a wealth of data is collected by researchers for various projects across Europe. However, this data tends to be fragmented and difficult to access or not at all accessible.
Type of data needed
Marine data, particularly metocean data, is used through the entire lifecycle of project implementation, from feasibility studies and site assessments to the conceptual design and design testing in order to ensure the suitability of the site, structural soundness of the infrastructure and for better understanding the long-term maintenance of assets. According to expert input, while more widely available metocean data cannot replace site specific data collection, as crucial environmental parameters can vary drastically over short distances in marine environments meaning developers need a 'high resolution picture' of the specific site, it could be highly valuable at other stages of the certification process, such the conceptual design phase and elaborating an effective maintenance strategy. This data includes the entire range of typical metocean parameters that are commonly collected.
Marine knowledge 2020
One of the central goals of Marine 2020 is the reduction in uncertainty concerning knowledge of the oceans and seas so as to provide a sounder scientific basis for managing future changes, such as the assessment of new offshore wind technologies. Marine Knowledge 2020 has the potential to play a crucial role in opening up the vast amounts of relevant marine data that exist in the private and public sphere, but are

currently difficult to access for public and private researchers alike.

Innovative services and benefits
Current/ future services to be developed
With the wide-scale deployment of relatively untested technologies, the certification process provides crucial assurance to insurers that offshore wind technologies are sound and can withstand both normal 'wear and tear' and extreme conditions. Many insurers are currently uncomfortable extending certain types of coverage. High levels of capital investment are needed over relatively long periods in order to realise Europe's offshore wind energy aspirations. If investors and developers don't have the capacity to mitigate that risk through proper insurance instruments, it could prove to be a major barrier to the expansion of the sector in the future. Currently, insurers are hesitant about extending coverage to include things such as defects. This means that even if a wind farm operator has all risks coverage, if a design defect presents itself, insurance will not cover the cost of fixing it. Likewise, serial failure is typically not covered in the industry, meaning that if the discovery of a defect in any insured property suggests that a similar defect exists in any other item, the insurer has the right to suspend forthwith coverage in respect of damage due to or arising from that particular defect. Only recently in 2012 did the first insurance company offer serial loss coverage for an offshore wind project. These types of insurance products are essential for giving investors and operators more certainty in the funding of major projects.
Economic Benefit
The offshore insurance industry is growing fast and attracting new players quickly. Some estimates put the property and engineering line insurance premiums at over € 1 billion by the end of the decade[104]. Insurance itself represents only a limited share of an offshore wind project's total cost, around 4%, or about £ 6 to 8 million per year for a 500 MW project for typical coverage (property, business interruption…)[105]. However, the insurance sector for offshore wind is still relatively immature, particularly when it comes to post-warranty operational insurance. Insurers tend to be sensitive to the introduction of new turbine technology and may increase premiums significantly as a result, especially during the early stages of deployment. Most projects thus far have been built in shallow areas of the North Sea, but in the future, installation may be as far as several hundred kilometers away from the coast. Technologies are evolving quickly as more cost-effective and efficient solutions are discovered and, as farms move further away from sure, they are growing substantially in size (in terms of the size of the turbines and the size of the farms themselves). Insurance has an important role in supporting investment in offshore wind projects by providing security for investors. In the future, there is the risk of inadequate coverage for the level of investment needed. Certifying designs and subjecting prototypes to rigorous testing using marine data, particularly metocean data, will thus play an important role in allowing underwriters to keep up with technological advances. Furthermore, predicting remaining useful life under normal operating conditions will allow operators to better manage their assets and adapt up-keep and maintenance strategies.

Main data sources
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[104] 'Offshore Wind Energy in Europe, Wind for Insurers, Too?'
[105] Offshore Wind Cost Reduction Pathways Study

'Load Analysis and Certification of Offshore Wind Turbines'. Argyriadis & Schwartz, 2009. http://www.risoe.dk/vea/recoff/documents/sec_7/recoffdoc031.pdf 'Offshore Wind Energy in Europe, Wind for Insurers, Too?', GenRe http://www.genre.com/sharedfile/pdf/Topics19_Stein-en.pdf Offshore Wind Cost Reduction Pathways Study - Finance Workstream PwC http://www.thecrownestate.co.uk/media/305094/Offshore%20wind%20cost%20reduction%20pathways%20study.pdf 'An Insurance Perspective on Offshore Wind Projects' DNV http://www.dnv.com/industry/energy/publications/updates/wind_energy/2011/windenergy_3_2011/aninsuranceperspectiveonoffshorewindprojects.asp 'Oceans of Opportunity : Harnessing Europe's large domestic energy source'. European Wind Association 2009. http://www.ewea.org/fileadmin/ewea_documents/documents/publications/reports/Offshore_Report_2009.pdf Managing risks through product certification http://www.euinfrastructure.com/article/Offshore-wind-farms--managing-risks-through-project-certification/ Power from Offshore Wind Farms – Nothing Happens Without Insurance http://www.talanx.com/konzern/themen-im-konzern/tik-archive/archive-2012/offshore.aspx?sc_lang=en
Input received from: Qing Yu, Managing Principal Engineer, ABS Offshore

6.5.3 Extend the coastal tourism season

Case 7: Coastal cleanup and awareness raising to attract and develop sustainable eco-tourism

Case presentation: problem definition & opportunities
Overall context
There is a strong mutual dependency between coastal tourism and the environment. Hotspots of biodiversity are often tourism destinations and tourists seek out a healthy environment (e.g. clean water, clean air, unspoiled landscapes). Aspects like quality and health are very much linked to biodiversity and represent ways to explain the benefits of biodiversity. For instance it may be hard to assign economic value to a rare bird, but looking at the revenue generated by the bird watching industry, for example, can help raise awareness of the value of preserving wildlife. In Scotland, the Royal Society for the Protection of Birds estimates that £ 5 million is spent annually by tourists wishing to see White-tailed Eagles on the Isle of Mull alone.[106]   The coasts are under very high population pressure due to rapid urbanization, with more than half of today's world population living in coastal areas and coastal areas attract a disproportionate amount of tourism flow. In parts of the Mediterranean region for example, tourism is the first economic activity for islands like Cyprus, Malta, the Balearic Islands and Sicily. World Tourism Organisation forecasts estimate that international tourist arrivals to the Mediterranean coast will amount to 346 millions in 2020, up nearly 150% from 200 million foreign visitors per year at the turn of the century[107]. Mass tourism has been associated with destruction of pristine areas, pollution and overdevelopment, not to count the numerous socio-cultural disruptions it can engender.   Biodiversity, which the Convention on Biological Diversity defines as the ""the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part" has been increasingly negatively affected by human activity, including tourism. In Europe, like elsewhere in the world, biodiversity is deteriorating. 25% of marine mammals, 15% of terrestrial mammals and 12% of birds are threatened with extinction[108]. Moreover, 62% of European habitats and 52% of European protected species included in the "Habitat" Directive have an unfavourable conservation status[109]. Thus, unbridled tourism development in Europe's coastal areas is a threat to biodiversity, however, biodiversity can also be a boon to the tourism industry, attracting a new clientele of travellers interested in experiencing the rich biological diversity of coastal habitats.   There is a strong need for cooperation of all players in coastal areas in order to develop a more sustainable tourism model, which takes into account fauna, flora and tourists demands. This is especially critical when one takes into account that that highest levels of marine biodiversity are found near the coast, where the diversity of habitats can support more varied lifeforms.   These evolutions provided crucial momentum to a strong trend born at the beginning of the 2000s advocating the promotion of eco-tourism as a sustainable solution for tourism. Although the concept of eco-tourism is difficult to define, it does have some consistent features: › The destination itself is usually an unpolluted natural area.   › Its attractions are the flora and fauna, and its entire bio-diversity.

[106] http://www.rspb.org.uk/Images/Birdcrime_2011_edit_tcm9-324819.pdf
[107] http://pub.unwto.org:81/epages/Store.sf/?ObjectPath=Shops/Infoshop/Categories/TourismForecasts
[108] EEA, 2010
[109] EEA-ETC/BD, 2009

- Eco-tourism should support the local economy and its indigenous atmosphere.
- It should contribute to the preservation of the environment, and promote the importance of conserving nature.
- 'Eco-trips' often include a learning experience.

Although eco-tourism is often associated with discerning tourists seeking out adventure in secluded corners of the world, it should also be understood to include here increasing demand for leisure activities linked to pristine, protected areas. As cheap airfare opens up new horizons for European budget travellers, many of Europe's unsustainably managed coastal areas are having trouble competing with unspoiled coastal areas beyond Europe's borders.

The past decades have seen an increasing acknowledgement of the need to protect Europe's biodiversity and the synergies that exist between protection and the sustainable expansion of tourism activities around these resources. While a number of tourism's negative consequences have been identified, it also represents an important source of financing for protected areas.

The European directive on Habitats and Birds has created a network of Natura 2000 protected areas, both on-land and offshore. A wide range of data is collected by Member States to implement EU Directives such as the Water Framework Directive, the Bathing Waters Directive, the Habitats Directive, and, most recently, the Marine Strategy Framework Directive. This situation is good for more eco-tourism initiatives all across Europe, as it has helped to highlight the unique and varied coastal ecosystems across the Member States. The new regulations are also helping to amass useful data on these species and their habitats. The annexes to the Habitats and Birds Directives list nine habitat types, 29 seabirds and 16 other marine animals in need of protection in view of their precarious conservation state. These include such well known species as the Mediterranean monk seal, the loggerhead sea turtle, and the bottlenose dolphin, as well as rare habitats such as cold water reefs and underwater prairies.

The need for marine knowledge in Europe

Current knowledge

Large amounts of data are available on various parameters such as pollution and the health of endangered species, which are essential to adopting sustainable development strategies for Europe's coastal tourism industry. Collection of this data has largely been based on disparate EU and national Member State regulations. While, on the EU level, the coherence and compilation of this data has made great strides, thanks, in particular to environmental regulations and directives such as the Marine Strategy Framework Directive, a coherent framework for the systematic use of this data within the context of coastal development has been lacking.

Currently, a Commission proposal for a directive for maritime spatial planning and integrated coastal management is seeking to a "systematic, coordinated, inclusive and trans-boundary approach to integrated maritime governance".[110] The proposal specifies that due regard should be given to these various pressures in the establishment of maritime spatial plans and integrated coastal management strategies and that healthy coastal and marine ecosystems and their multiple services, if integrated in planning decisions, can deliver substantial benefits in terms of food production, recreation and tourism, climate change mitigation and adaptation, shoreline dynamics control and disaster prevention. [111] In particular, article 10 provides for the collection of necessary data for the elaboration and management of local strategies, including environmental data. Along with Marine 2020, this directive has the potential to play an important role in adopting a more integrated approach to the understanding and sustainable management

[110] COM(2013) 133 final
[111] COM(2013) 133 final

of tourism activities on local biodiversity.

Secondly, there is increasing cooperation within the tourism industry itself, on how to sustainably manage the development of their activity and how to successfully develop new forms of ecotourism, which can be challenging given the delicate environments in which they operate. Ecotourism is still considered an alternative form of tourism, and has not been strongly advocated for as a solution for longer coastal seasons. Ecotourism destinations can be characterised as standalone tourism suppliers, meaning that although competition can be useful, often cooperation among such small operators' yields significantly better overall results. Harmonising nature conservation and tourism is also an important condition of sustainability.

Existing initiatives

A number of public and private initiatives exist, bringing together actors across Europe in order to improve the quality and coherence of marine environmental monitoring and help identify and mitigate threats to Europe's marine ecosystems.

CLEANSEA aims to generate new information on the impacts (biological, social and economic) of marine litter, develop novel tools needed to collect and monitor litter and protocols needed for monitoring data (litter composition and quantities) and evaluate the impact of mitigation strategies and measures in order to provide options to policy makers in the EU. In particular work packages 2 and 3 are addressing the biological impacts and technical aspects of marine monitoring, monitoring tools and applications.

The European Marine Ecosystem Observatory (EMECO) group brings together 17 institutes, from nine countries that monitor, model, and research marine ecosystem threats, health, functions, and interactions. By sharing resources, expertise, data, and information, the EMECO seeks to provide a more holistic view of European marine ecosystems available. Many of the partners also have an advisory role in management and policy decisions relating to European marine ecosystems.

There are many initiatives to develop ecotourism on the coasts of Europe, and to encourage the sharing of best practices in terms of research and management, whether on the Mediterranean coast or on the North Atlantic Coast.

ECOLNET

The introduction of codes of conduct, quality assurance, labelling and service standards certification have all helped the industry establish universal principles of best practice for the sustainable development of eco-tourism across all types of tourist activity from tour operators to restaurants. One example of this is the European Ecotourism Knowledge Network (ECOLNET), a project running from 2010 to 2013 and co-financed by the Lifelong Learning Programme aims to create an Ecotourism network, that brings together a variety of stakeholders and develop innovative evaluation tools and learning products for sharing knowledge among the network in order to facilitate quality certification through the European Ecotourism Labelling Standard (EETLS). The EETLS was developed by two previous Leonardo da Vinci projects in compliance with the Global Sustainable Tourism Criteria of Global Sustainable Tourism Council.

The Adriatic Coast

Countries alongside the Adriatic Coast are trying to increase ecotourism on the coast. Italy has 21 National Parks, 99 Regional Parks, 332 Regional Reserves, 145 State Reserves, 47 Marsh reserves and 17 Marine Reserves, which are protected zones managed either by the State in some form - Regional Councils, Provincial Councils and Municipalities - or by the environmental and protection associations such as Italia Nostra, WWF, Lega Ambiente, Greenpeace, LIPU, Touring Club, etc. Slovenia hosts a natural reserve with a rich fund of marl and sandstone and the eighty-meter Strunjan cliff, a sanctuary for more than 150 bird species. In Croatia, 8 national parks and 11 natural parks protect the marine landscape and species.

Archipelago Islands marine wilderness

The park in Finland is an ensemble of 2000 rugged, rocky islands and forms the core of the great Archipelago Sea Biosphere Reserve, one of the largest archipelagos in the world. In it live colonies of grey and ringed seals, moose and small rodents, as well as white tailed eagles, the pride and emblem of the archipelago.

It is the first unique example of a marine wilderness. This is the only continuous marine zone in the Baltic Sea free of fishing. Strict rules of wilderness protection prevent visitors from entering this part but other areas of Archipelago NP - accessible if respecting certain rules - provide similar experiences.

Type of data needed

In order to maximise the positive synergies between environmental protection of coastal areas and the sustainable development of eco-tourism, data on the effects of human activity in general and tourism in particular on the health of Europe's marine ecosystems is needed. Current environmental directives impose data collection for specific species in the greatest danger. However, focusing only on species levels can be somewhat myopic. Data needs to be integrated in order to provide a more holistic picture.

The activities such as wildlife watching, in order to mitigate the negative impact of increased tourism flow, a more precise knowledge of meteorology, water quality, coastal erosion is necessary.

- On the species and their habitats: for example, for underwater observation, the increased knowledge to predict where the fish, dolphins and sea mammals are more likely to be and less likely to be disturbed by tourists. A better understanding of the movements of marine life would increase the possibilities of harmless wildlife observation activities.
- On the impact of tourism on the preserved habitat: with shared past observations on specific sites in Europe, the possibility to predict the future will be enhanced and the spatial planning of coastal and maritime areas will be able to be adapted and better suited to the needs of all stakeholders.

The OECD report on Green Innovation in tourism[112] points out that some of the main drivers supporting sustainable tourism investment decisions are consumer demand changes; business actions to reduce operational costs and increase competitiveness; coherent policies and regulations for environmental protection; technology improvements; private efforts for environmental and social responsibility and natural resource conservation. However, **a cross-cutting barrier is the lack of understanding of the value created from the greening of tourism**. Their survey of members identified by countries drivers such as an increased focus on environmental issues and consumer demand to be particularly important for green innovations, while information gaps and potential or perceived investment cost for businesses were the barriers mentioned most often. More integrated and widely available information on the effects of tourism on the environment and the benefits of greener tourism could play a role in raising public awareness and helping evolve consumer preferences.

Marine knowledge 2020

"The reporting requirements of the Marine Strategy Framework Directive are the basis of the marine component of the Water Information System for Europe, WISE-Marine. Under Article 19 of the Marine Strategy Framework Directive, there is a requirement for Member States to provide access to data resulting from the assessments and monitoring."

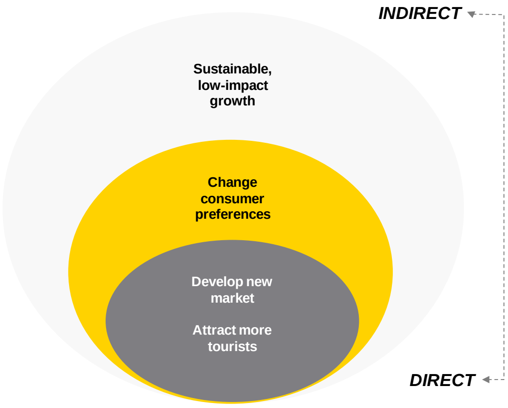
The Commission Staff Document of December 2012 on an "Overview of EU policies, legislation and initiatives related to marine litter" mentions how the marine knowledge 2020 initiative aims to improve access to data on the sea, including the distribution and composition of marine litter.

[112] Green innovation in tourism, working paper, OECD 2013

Innovative services and benefits
Current/ future services to be developed
The objective of the innovative service is to: › Increase the quality of the "ecotourism experience", extending the tourism season and therefore allowing for a better socio-economic development of the region › Protect the biodiversity on the coasts of Europe to ensure a more sustainable tourism › Decrease the negative impact of tourism flows on the environment, both terrestrial and underwater Many different services could be developed: › An information platform with data on the localisation of species, their natural habitats in order for constructors to be able to preserve the environment › Consolidated databases for tourists, to know the quality of water on the internet and be able to plan ahead their visits: for instance, on http://www.izor.hr/bathing/bathing.html, tourists can see the quality of bathing waters along the Croatian coastline. This map identifies all Natura 2000 sites across Europe. A great number of them are located on the coast, North Atlantic and Mediterranean basin alike, which increases the possibilities for coastal eco-tourism in Europe. In Portugal Since the 1990s, Azores has registered an increase in the number of tourists that come in search of a natural experience. A set of nine "Islands' Parks" has been created throughout the Azorean archipelago. These regions aim to protect Europe's remaining natural areas, in remote and isolated islands like the Azores. At the same time they are devoted to the practice of nature based tourist activities, and nature based tourism is in Portugal. In order to evaluate, prevent and minimize the impacts resulting from the tourist activity in the Azores, a research project has been launched in the beginning of 2010 named, "Application of a model of sustainable tourism to areas of Natura 2000 in the Azores". So far the preliminary surveys conducted on the environmental perception of both tourists and nature based tourism enterprises, show that **some work has to be done on both sides in terms of environmental education, to prevent future environmental degradation that may compromise the fate of this kind of economic income.** An important potential market: the example of Bird watching Different studies on bird watching demonstrate that it is an important market: 51.3 million Americans claim to be birdwatchers. In the USA birdwatchers were estimated to have spent over $US 2.5 billion in 2009. In the UK, expenditure is estimated at $US 500 million each year. Considering the diversity of birds on the European coast, there could be significant growth potential in Europe.
Economic benefit
Tourism is the third largest socioeconomic activity in the EU after the trade and distribution and construction sectors. There are some 1.8 million businesses, primarily SMEs, employing approximately 5.2% of the total workforce. Maritime tourism accounts for 3 million jobs. In 2004, ecotourism/nature tourism was growing globally three times faster than the tourism industry as a whole,[113] and the trend is continuing nowadays, ecotourism and "green tourism" is constantly increasing.[114] Eco-tourism represents a new market to develop for coastal communities, which represents a sustainable use of

[113] World Tourism Organization, press release, June 2004
[114] Interview with Peter Haxton, Policy Analyst, OECD

their natural biological resources. Because of the lack of comprehensive data on this relatively young industry, it is difficult to provide sound estimate for the growth potential of this market in Europe, although it is clear from WTO estimates that ecotourism has proven to be one of the fastest markets in the industry.



Nevertheless, anecdotal evidence suggests that developing this industry could provide substantial direct and indirect economic benefits. Taking the example of birdwatching tourism introduced earlier, Kerlinger and Brett[115] reviewed 5 birdwatching locations in North America and concluded that each would attract between 6,000 and 100,000 annual visitors, creating between $US 2.4 million and $US 40 million in economic impact. In Scotland, the Royal Society for the Protection of Birds estimates that £ 5 million is spent annually by tourists wishing to see White-tailed Eagles on the Isle of Mull alone.[116] Europe has a vast array of biodiversity and some 66,000 kilometres of coastline, providing it with ample opportunity for future development. Furthermore, the outermost regions harbour strong potential as well for the development of ecotourism in Europe, especially with wildlife watching activities. Recent estimate by the Caribbean Whale Conservation Forum put potential income earned by a regional whale watching industry at about $US 24 million a year.[117]

Beyond developing new markets around local biological resources, it is also becoming increasingly clear that investing in cleaning up coastal zones provides important economic benefits. Even if tourists are not drawn by local bird watching, the success of directives such as the Bathing Water Directive proves that vacation goers care considerably about the environmental health of their vacation destinations.

In Blackpool in the UK, the pollution programme manager for the Marine Conservation Society has estimated that Blackpool could face losing about £1 billion in lost revenue over 15 years if it does not address water quality issues. According to an EU survey in 2010, 500 EU beaches did not reach minimum quality standards. There is potential therefore that cleanup may result in avoided losses of up to €585 billion over 15 years.

As another example, a 2004 study by Hanemann & Pendleton looked at economic benefits of improving beach water quality at Malibu Surfrider Beach and demonstrated that improving water quality at Malibu Surfrider would increase the number of visitors by 1,538 visits per year for a total economic impact (local spending) of $US 45,000/year[118]. Another study commissioned by the US National Oceanic and Atmospheric Administration found that changing the water quality at Long Beach from a Heal the Bay baseline 2000 annual average score of 2.8545 to the baseline score for Huntington City Beach of 3.915 will result in an annual increase in day use from residents of the four-county study area to Long Beach in the amount of 5,633 person-days of use.

These isolated examples show the strong economic potential for ecotourism in Europe. Finally, increasingly available information on the environmental consequences of unsustainable tourism can play a role in changing European consumer behaviour by raising awareness of local environmental conditions (e.g. the Bathing Waters Directive summary report) and promoting greener forms of tourism, such as eco-tourism. It will

[115] Kerlinger, P. & Brett, J.J. (1995), Hawk Mountain Sanctuary: A case study of birder visitation and birding economics.
[116] http://www.rspb.org.uk/Images/Birdcrime_2011_edit_tcm9-324819.pdf
[117] http://archive.defra.gov.uk/wildlife-pets/wildlife/protect/whales/documents/whale-watching.pdf
[118] http://surfeconomics.blogspot.co.uk/2009/11/cost-of-poor-water-quality-at-surfrider.html

also help local citizens draw the concrete link between the economic benefit of protecting and sustainably exploiting local biological resources.
Data sources
A sustainable tourism in the Azores implies the environmental awareness of both stakeholders and tourists, A. M. Ventura, 2011 Green Innovation in Tourism (working paper), OECD 2013 Hawk Mountain Sanctuary: A case study of birder visitation and birding economics, Kerlinger, P. & Brett, J.J. (1995). http://www.oeconomica.uab.ro/upload/lucrari/1020082/14.pdf www.panparks.org http://www.ukotcf.org/pdf/calpe/calpe125-144.pdf http://www.onecaribbean.org/content/files/BirdwatchingCaribbeanNicheMarkets-2.pdf Tourism and Biodiversity: the Balearic experience, Cristian Ruiz Altaba & Lina Ponsell, Calpe 2000: Linking the Fragments of Paradise http://archive.defra.gov.uk/wildlife-pets/wildlife/protect/whales/documents/whale-watching.pdf
Input received from: Peter Haxton, Policy analyst, Tourism unit, CFE, OECD

Case 8: Artificial reefs – surf and diving opportunities

Case presentation: problem definition & opportunities
Overall context
In order to extend the tourism season, some tourism industry actors are currently developing innovative solutions that would allow tourists to enjoy the natural characteristics and activities throughout the year. Artificial reefs can be seen as an innovative solution to increase sustainable coastal tourism through surfing and diving revenues, as they can protect marine species and therefore also create potential dive and game fishing sites. The situation is unique in each sea basin. In the Mediterranean, although the underwater fauna and flora in Europe is highly diverse and a point of interest for both the environment and the tourism industry, the 1970s saw the beginning of a decline, which prompted many projects in an attempt to save it. Along the Atlantic coast, the situation is different due to slightly colder water. Surfing is more developed than diving, especially in Ireland, France and Galicia, where the quality of the waves is consistent and satisfying for surfers. Two main artificial reefs in Europe illustrate this double aim of protecting the fauna and flora, whilst developing tourism in an environmentally-friendly manner: › In Gibraltar, an artificial reef project was launched by divers who noticed a decrease in the diversity of the fauna and flora. The reef was built from 1975 to its latest addition in 2008. The project was adapted throughout the years to both environmental conditions (storms destroyed the reef in the first years) and European policies. › An artificial reef in Boscombe, Bournemouth, UK, opened in November 2009. The multi-purpose reef was expected to create waves up to 30% larger and double the number of surfing days annually. Construction on this reef began in June 2008, and was completed in August 2009.

The need for marine knowledge in Europe
Current knowledge
Artificial reefs have been created for surfing, coastal protection, habitat enhancement and coastal research. Artificial reefs tend to develop in more or less predictable stages: › First, where an ocean current encounters a vertical structure, it can create a plankton-rich upwelling that provides a reliable feeding spot for small fish, which then draws in pelagic predators. › Next come creatures seeking protection from the ocean—hole and crevice dwellers. › Opportunistic predators also appear, waiting for their prey to venture out. Over months and years the reef structure becomes encrusted with algae, tunicates, hard and soft corals, and sponges At Gibraltar, the artificial reef was built as an underwater scrapyard: initially experiments were tried with tyres chained together but sand movement and currents proved to be too strong and washed the articles away or buried them. Concrete polypods were tried but they also suffered from tidal force as did the tyres and proved too expensive. This was followed by sinking of cars and monitoring the effects of sea life upon them. Finally boats and barges were to be donated by the Gibraltar Port Authority and local marinas. These boats were thoroughly cleaned and emptied of all pollutants prior to sinking and every location mapped. At Boscombe, the reef was built from large sand-filled textile containers, totalling 13,000 cubic meters. It was designed purely as a surfing break.

Existing initiatives

The reef in Gibraltar is monitored quite closely as it is the longest standing project of marine conservation in the Bay of Gibraltar, and an important point of passage for navigation purposes.

The NEA II project also included a research project in North Devon, to investigate the current provision of public transport with watersports equipment carriage facilities and equipment storage on beaches as well as to identify opportunities for developing an eco-concept of sustainable bus transportation and storage facilities along the Atlantic Coast. People who do not have their own mode of transport find it difficult to access beaches or lakes to take part in regular watersports activities, especially if they want to take their own equipment with them. This action seeks to explore innovative approach to green transportation and storage facilities for watersports users along the Atlantic Coast.

This said, we have not identified any initiatives specifically relating to marine knowledge on artificial reefs.

Type of data needed

In order to create stable, efficient and environmental friendly artificial reefs, there is a need for more information on:

- Bathymetry and topography: how and where to place the wrecks
- Marine currents and meteorology: the strength that the reef will have to resist and the impact on current flows
- The quality of water, salinity: to know what kind of material to use in order to limit the impact on the quality of water and the fauna.

To be sure to increase tourism flows, the clarity of water is also important data, in order to extend diving season: the potential tourist must be assured that the quality of the "tourism experience" will be the same all year long.

There is also the need to study the impact on coastal erosion: as artificial surfing reefs usually resemble a "submerged breakwater", proponents suggest benefits beyond surfing conditions. Many coastlines are subject to powerful waves that crash directly onshore. An artificial reef 150-300 yards offshore might create surfing opportunities and, by dissipating wave energy, make swimming safer and reduce coastal erosion.

Marine knowledge 2020

There is no specific mention of the potential of artificial reefs as part of the Marine Knowledge 2020 initiative,

Innovative services and benefits

Current/ future services to be developed

The objective of the innovative services is to:

- Create new tourism activities
- Create new potential dive and game fishing sites

Types of services may include:

- Artificial reefs to create new possibilities for diving, fishing, and as well as other nautical activities.

<u>Illustrative example: the Boscombe reef</u>

The innovative reef, created with geotextile bags filled with sand which had been stockpiled on the shore for a beach replenishment project, was successful in producing a new wave at Boscombe which was rideable for experienced surfers and boogie-boarders. But the new wave on the reef was significantly different to the waves that are available on the natural beach around the Boscombe Pier. It was less consistent than the neighbouring beach, when it had been hoped that the reef would increase the consistency of the surfing waves in the area. And the wave is more challenging than was first anticipated, breaking powerfully and quickly on take-off, making it difficult for even early intermediate surfers to enjoy the wave.

Economic benefit

The introduction of artificial reefs into European waters provides a number of potential environmental and economic benefits.

Although many are skeptical of the larger-scale impact of artificial reefs, locally, they have been shown to play a positive role of biological replenishment. Fish and other aquatic organisms are attracted to the new structures and begin to populate and breed in and around them, which in turn attracts more fish and aquatic life as a food chain develops. The populations that build up around artificial reef sites provide a source of biological replenishment to local populations of marine vertebrates and invertebrates and can be a means of mitigating local habitat loss[119].

Aside from the environmental benefits that have been observed, artificial reefs can also represent considerable economic benefit to local communities because of the positive effects they can have in attracting tourists and, more generally, revitalizing the local economy. While artificial surfing reefs are new to the Northern Hemisphere, artificial reefs of various sorts have been in use in European Waters since the 1970s[120], although little research has been done on their economic benefit.

Depending on its size and the method used, creating an artificial reef can cost from $US 46,000 to $US 2 million.[121] Florida has the most permitted artificial reefs in the United States, with approximately 2,700 artificial reef deployments located off 34 coastal counties. The economic impact and use values associated with artificial and natural reef systems in southeast Florida were analyzed by Johns, Leeworthy, Bell, and Bonn (2001). The study found that non-residents and visitors annually spent $US 1.7 billion on fishing and diving activities associated with artificial reefs. The annual recreational use value associated with existing artificial reefs in the region was estimated to be $US 84.6 million. This annual value discounted into the future produced a discounted value of $US 2.8 billion[122]. Various other studies have found the market value (expenditure by divers) of artificial SCUBA reefs to vary between $US 28 at a location in Eliat, Israel to $US 194 at an artificial reef in Texas. [123]

In Europe, the first artificial surfing reef in Boscombe was built at a cost of £ 3 million and was a part of a larger £ 11 million investment scheme that redeveloped the seafront area, including a refurbishment of the pier. However, the impacts of this investment project on surf conditions and the local economy have been mitigated, embroiling the local government in scandal. A 6 Month Assessment prepared by Dr. Mark Davidson, an Associate Professor in Coastal Processes at Plymouth University found that the reef was underperforming on a number of criteria and local press has reported disappointing impacts on surfing conditions and the economy.[124] Another report published by Emma Rendle found that the performance of the handful of artificial surfing reefs was still debatable.[125] The reef was closed in 2011 for safety reasons after sustaining damage. While experiences with artificial reefs for various purposes, from purely environmental to

[119] FAO Background on Artificial Reefs: http://www.fao.org/fishery/topic/14861/en
[120] Jensen 'Artificial Reefs of Europe; Perspective and Future'. 2002.
[121] Pendleton 'Understanding the Potential Economic Impacts of Sinking Ships for SCUBA Recreation'. 2005.
[122] 'Adams, Lindberg & Stevely 'The Economic Benefits Associated with Florida's Artificial Reefs'. 2006, 2011 (revised)
[123] Pendleton 'Understanding the Potential Economic Impacts of Sinking Ships for SCUBA Recreation'. 2005.
[124] 'Surfs Up... but not at the Boscombe Reef!' Bournemouth Daily Echo. 10 November 2010:http://www.bournemouthecho.co.uk/news/features/surfreef/surfreefstories/8628632.Surf___s_up____but_not_at_the_reef_/
[125] Rendle, Emma 'An Evaluation of the Physical Impact and Structural Integrity of a Geotextile Surf Reef'. 2011

SCUBA, fishing and surfing, have been varied, there is clear evidence that these reefs can have positive impacts, creating value for local economies and attracting tourists. While suitable locations in Europe may vary, there is clearly potential to further exploit this idea in other coastal communities in Europe.

Data sources

http://ngm.nationalgeographic.com/2011/02/artificial-reefs/harrigan-text

The impact of surfing on the local economy of Mundaka, Spain, M. Murphy, M. Bernal, 2008

http://www.washingtonpost.com/surfonomics-quantifies-the-worth-of-waves/2012/08/23/86e335ca-ea2c-11e1-a80b-9f898562d010_story.html

http://www.dolphin-research.com/projectdetail.php?id=14

http://theblogaquatic.org/2012/09/14/surfonomics-how-much-money-is-a-wave-worth/

Input provided by:

Peter Haxton, Policy analyst, Tourism unit, CFE, OECD

Case 9: Protection against coastal erosion

Case presentation: problem definition & opportunities
Overall context

With the development of coastal tourism, and the migration trend towards the coast, coastal erosion has turned into a problem of growing concern. All coasts in Europe are subject to coastal erosion. Among the problems most commonly encountered in Europe are:

- the abrasion of the dune system as a result of a single storm event, which may result in flooding of the hinterland. This is best illustrated by the cases of the Dutch Coast, Wadden Sea, Rosslare, Hel peninsula, Sylt, Camargue, Vagueira, and Castellon;
- the collapse of properties located on the top of cliffs and dunes as documented in the cases of South Down, Luccombe, Normandy, Hyllingebjerg – Liseleje, Castellon, Vale do Lobo, and Estela;
- the undermining of sea flooding defences as a result of foreshore lowering such as in Knokke-Zoute, Humber Estuary, Ystad, Chatelaillon, Sable d'Olonne, Donegal, or coastal marsh squeeze such in Elbe and Essex;
- the loss of lands with economic value such as the beaches of De Haan, Sylt, Mamaia, Vecchia Pineta, Giardini Naxos, Sable d'Olonnes, and Ghajn Tuffieha, the farming lands of Essex or with ecological value such as the Scharhoern Island along the Elbe estuary.

3 case-studies illustrate the importance of coastal erosion in the last 20 years in Europe.

- De Haan : North sea

  De Haan is an important seaside resort in Belgium. The beach is therefore of great importance for tourism in this area. Erosion of the beach can threaten the tourism and recreational function of the beach. Furthermore, the function of urbanisation (safety of people and investments) was at risk because of the erosion. The beaches, partly built to stabilise the dune belt, and the sloped seawall are a part of the coastal protection system and were threatened by the occurring erosion.

  Surveys of the coastal zone in De Haan indicated a severe regression of the overall beach/dune profile from 1980 to the 2000s and particularly after the February 1990 storm. The beach had almost disappeared in the vicinity of De Haan and threats of flood became very real; even the sloped seawall foundation was eroded.

  Erosion at De Haan occurs mainly after repeated storm surges and is enhanced by high water levels.

- Isle of Wight : Channel

  On the Isle of Wight, coastal erosion has led to coastal landslide problems, especially at Ventnor. The whole town has been built on an ancient landslide complex, and though present day coastal retreat is minimal, long-term erosion has helped shape a belt of unstable land which extends almost 1km inland, and 12km in length.

  Contemporary movements within the town have been slight, but because of the high density of population (over 6,000 permanent residents), the cumulative damage to roads, buildings and services, and also to public and insurers confidence has been substantial.

- Regione Marche in Italy

  The Marche region in Italy is densely populated (565,200 people in a 959km2 area). Almost the entire coastal line of sand or gravel beaches is an important tourist destination, concentrated in the period of May to September.

  Coastal erosion represents one of the most significant factors of concern with regards to the stability of the economic system connected to the tourism industry.

The need for marine knowledge in Europe
Current knowledge

Coastal erosion is induced by both natural factors and man-made actions. Among the natural factors directly linked to coastal erosion:
› Waves: the breaking wave is the mechanical cause of coastal erosion in most of cases reviewed and in particular on open straight coasts such as those of Sussex, Ventnor, Aquitaine, Chatelaillon, Holland, Vagueira, Copa do Vapor, Estella, Valle do Lobo, Petite Camargue, Marina di Massa, Giardini Naxos, Ystad, or Rostock;
› Winds participate in the landwards movement of dunes (Aeolian erosion). This is particularly visible along some sandy coasts of those Aquitaine, Chatelaillon, Rosslare, and Holland;
› Tides: coasts along which the tidal range exceeds 4 meters, all along the Atlantic sea (e.g. Vale do Lobo in Portugal), are more sensitive to tide-induced water elevation than micro-tidal coasts (i.e. tidal range below 1 meter).
› Near-shore currents:
  › As an example, long-shore drift is responsible of removing large volumes of sand in Vale do Lobo, Estela beach, Aquitaine, De Haan, Zeebrugge, Sylt or Jutland. Erosion induced by cross-shore sediment transport is best illustrated with the cases of Sable d'Olonne or Donegal.
  › As for tidal currents, their impact on sediment transport is greatest at the inlets of tidal basins or within estuaries such as in the cases of the Wadden Sea, the Arcachon basin, the Western Scheldt and the Essex estuaries. In some places, near-shore currents, and associated sediment cells, follow complex pathways as epitomised by the cases of Estela or Rosslare, or Falsterbo.
› Storms cause high water levels and highly powerful waves. They can damage coastal infrastructure and can cause beaches and dunes to retreat by tenths of meters in a few hours, or may considerably undermine cliff stability. A significant number of cases have reported extreme storm events that severely damaged the coast: De Haan and Holland (storm of 1976), Chatelaillon (1962, 1972, 1999), Cova do Vapo and Estela (2000), Normandy (1978, 1984, 1988, 1990), and Donegal (1999).
› The rise of sea levels also has a strong impact: though more severe in sheltered muddy areas (e.g. Essex estuaries), this phenomenon is known as a significant factor of coastal erosion in all regional seas: Atlantic Sea (e.g. Donegal, Rosslare), Mediterranean Sea (e.g. Petite Camargue, Messolongi, Lakkopetra), North Sea (e.g. Holland coast), Baltic Sea (e.g. Gulf of Riga), and Black Sea.
› Slope processes: a wide range of land-sea interactions which eventually result in the collapse, slippage, or topple of coastal cliff blocks. The cases of Luccombe, Birling Gap, Criel-sur-Mer (Normandy), Sylt, Cova do Vapor, Vale do Lobo are particularly relevant in that respect.

Existing initiatives
According to studies[126], coastal sediment processes is not analysed often enough by promoters of projects impacting coastal processes. There are few Environmental Impact Assessment (EIA) reports that address coastal sediment processes as a serious environmental impact. The study mentions that EIA reports are still very difficult to obtain even after the

[126] Living with coastal erosion in Europe: Sediment and Space for Sustainability, PART IV – A guide to coastal erosion management practices in Europe: Lessons Learned, Eurosion, 2004

administrative authorities in charge of project consent have approved them.
Type of data needed
Because there is such a diversity of factors, natural and man-made, involved in coastal erosion (see above), in order to prevent, and prepare an appropriate response to coastal erosion, there is a strong need to share all available information: › On past observations of meteorological events that resulted in greater erosion (storms, etc), › On current water flows and wind flows to have a wide database all across the European coast, › On temperature of water which has a strong influence on coastal erosion (see above), › On topography and on bathymetry in order to prepare context appropriate responses to coastal erosion. Because coastal erosion is difficult to replicate in a laboratory, the data ought to be real time observation data, which can be too expensive for some research institutes.[127] The THESEUS[128] project indicates there is a need of data for accurate risk assessment: › to develop probabilistic tools for estimating hazard scenarios related to climate variability and change › to improve the knowledge of vulnerability and resilience of coastal defences and of coastal environment for the purposes of mitigation plans › to evaluate coastal flooding damages to infrastructure, environment and human activities; impacts on society, including change of social cohesion, livelihoods, and opportunities
Marine knowledge 2020
"Coastal authorities need knowledge of erosion rates, sediment transport and topography to determine whether protection, accommodation or retreat is the most appropriate strategy for managing shorelines."

Innovative services and benefits
Current/ future services to be developed
The objective of the service is to develop an innovative coastal defence system. Types of products / services may include: › New products to protect the coast like Elastocoast. The revetment is plastic, and meant to resist environmental events. It is a joint research project between BASF Polyurethanes GmbH and the TU Hamburg-Harburg (TUHH): the suitability of the use of Elastocoast in coastal protection systems has been proven and the long-lasting stability under environmental influence has been demonstrated. In a further research cooperation with TU Delft and the engineering office ARCADIS (NL), additional tests and dimensioning procedures (GOLFKLAP) for the use of Elastocoast in accordance with international standards has been provided. › Subsurface Dune Restoration System: a construction under the sand that protects the shape of the dune and protects the coast against erosion.

[127] Living with coastal erosion in Europe: Sediment and Space for Sustainability, PART IV – A guide to coastal erosion management practices in Europe: Lessons Learned, Eurosion, 2004
[128] www.theseusproject.eu

- Water/ sand inflatable emergency response devices: easy to inflate structures to reshape the coast in case of strong wind of waves.

Existing/ ongoing initiatives:

- Research: the European co-financed Theseus project's general aim is the development of innovative methods for mitigation of flooding and coastal erosion hazard in the context of increasing storminess and sea level rise.
  - Within coastal engineering, THESEUS is proposing for the first time to adopt wave energy converters for beach defence purposes. The distance from the shore at which the converters can be placed to obtain incident wave attenuation and at the same time maximize secondary benefits will be investigated.
  - THESEUS also aims to address the issue of coastline stabilization and of the volumes of sand needed for beach maintenance. Plans of dredging and nourishment operations, management of borrow areas, reactivation of the littoral drift, estimation of plume dispersion will be analysed.
- New technologies by BASF tested in both Hamburg and Ile de Ré among other places

Economic benefit

Protecting against coastal erosion can provide a number of very direct economic benefits, from lowering insurance premiums, saving productive coastal land and protecting tourist destinations that provide a crucial injection of revenue for many coastal economies. Beyond these direct benefits (discussed more in depth in the two anecdotal cases presented below), there are also less tangible, yet equally if not more important benefits to protecting against coastal erosion. For example, A Portuguese study by Alves *et al*, using the Benefit Transfer approach, found that the total value of coastal ecosystem services in central Portugal amounted to € 193 million annually and that expected ecosystem service value losses amount to € 45 million by 2058.[129] Another study identified the various ecosystem services provided by coastal and estuarine ecosystems, which include, among many others, carbon sequestration, fisheries management, coastal erosion protection, nutrient cycling and water purification.[130] These indirect economic benefits created by coastal ecosystems serve to underline the importance of protecting Europe's coasts in general, and not just in highly populated areas where direct damage can be done to economic livelihoods.

To illustrate the more direct benefits of coastal protection, two anecdotal examples are provided.

Isle of Wight

Over the last 100 years about 50 houses and hotels have had to be demolished because of ground movement. The total cost of landslides in this area has averaged £ 1.4 million per year from 1980 to 2000 in terms of structural damage, insurance costs, engineering measures and monitoring.[131]

Landslide management involves reconciling a number of conflicting demands, including reducing risk to vulnerable properties, important economic resources and facilities, and protecting areas of scenic, geological or ecological importance. It is important, therefore, that management decisions are based on the best possible understanding of landslide systems and the wider environment, and how to manage and protect it. Landslide

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[129] Alves, Roebling, Pinto & Batista 'Valuing Ecosystem Service Losses from Coastal Erosion Using a Benefits Transfer Approach: A Case Study for the Central Portuguese Coast'. Journal of Coastal Research n 56, 2009.
[130] Barbier, Hacker, Kennedy, Koch, Stier & Silliman 'The Value of Estuarine and Coastal Ecosystem Services'. Ecological Monographs, 2011.
[131] McInnes, R., Tomalin, D. & Jakeways, J. (2000b) LIFE-Environment Project: LIFE – 97 ENV/UK/000510 1997-2000 Coastal change, climate and instability: Final Technical Report. Isle of Wight Council, Isle of Wight, UK

management will generally involve a partnership between a wide range of interests, including planners, developers, insurers, environmental managers and the public, together with engineers and geoscientists.

Marche region, Italy

Coastal protection works defend approximately 100 km (58%) of the coastline from coastal erosion; excluding steep cliffs areas (the two natural parks) and harbours structures. Almost 70% (90 km) of the beach shoreline has been protected.

Many different types of coastal defences have been tested and built; principally rock armourstone located directly on the shoreline where built structures are at risk of flooding, but also offshore rock barriers with crests slightly above average sea level (preventing erosion) or slightly below the surface of the sea (to promote environmental maintenance) – in some locations the techniques have been combined, due to the changing design priorities through time.

The gross economic income, directly due to coastal tourism industries (hotel accommodation and beach services), has been carefully estimated at EUR 1,070.00 Million (12.3 Million people x € 87/each per day).

Costs of coast protection strategies may be high: in Poland, a long-term (50 year) coast protection strategy has been developed, the annual cost of implementing this strategy is estimated to be € 20 million during the first 10 years, € 25 million during the next 15 years and € 28-30 million during the last 25 years. But this cost must be valued against the cost of consequences of coastal erosion.

Data sources

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http://copranet.projects.eucc-d.de/files/000105_EUROSION_De_Haan.pdf

McInnes, R., Tomalin, D. & Jakeways, J. (2000b) LIFE-Environment Project: LIFE – 97 ENV/UK/000510 1997-2000 Coastal change, climate and instability: Final Technical Report. Isle of Wight Council, Isle of Wight, UK

http://bcs.dep.state.fl.us/news/innovative/report/appendix_c/06-Subsurface_Dune_Protect.pdf

http://www.polyurethanes.basf.de/pu/Coastal-Defense

http://www.polyurethanes.basf.de/pu/Coastal-Defense/Referenzprojekte/Hamburg

http://www.polyurethanes.basf.de/pu/Coastal-Defense/Referenzprojekte/Ile_de_Re

6.5.4 Discovery of new bio-economy products

Case 10: Development of seaweed industry through new harvesting techniques

Case presentation: problem definition & opportunities
Overall context
The development of seaweed based products and the on-going research creates an increasing demand for quality seaweed. But in Europe, seaweed exploitation is currently restricted to manual and mechanised harvesting of natural stocks. European seaweed production, at around 1,3% of world supply, is focused around Norway and France, with a significant contribution from Ireland. Considering the majority of Asian seaweed resources are cultivated, the question must be raised as to whether there are similar opportunities in Europe. Many products can be seaweed based. Algae are proven to be a source of: nutrition, lucrative colloids, renewable energy, therapeutic health booster, food supplement for farm animals, organic manure, etc. The global industry turnover increased from $US 6.2 billion in 1994 to $US 7.2 billion in 2006[132]. Values have not been inflation-adjusted, but the trend is one of increased volume and static turnover. It reflects the significant cost-reduction brought about by cultivation practices. There is a much larger amount of seaweed available and mechanized operations have improved productivity allowing lower market prices Future development of the industry will also be driven by new uses for algae. Marine biomass is attracting a great deal of commercial and political interest **in particular for bio-fuel production.** Researchers have discovered that algae have the capacity, through photosynthesis to convert CO2 into molecules that form the chemical basis of diesel duel. Bio-fuels based on marine algae have undergone large scale tests, but marine algae applications are still under development and their energy contribution over the next decade is likely to be modest. The data on the production (strain development, cultivation) of quality seaweed, and the use of algae as sources of energy or raw materials is still insufficient.

The need for marine knowledge in Europe
Current knowledge
<u>On production and cultivation of seaweed</u> Existing industries having large scale cultivation plants are located in Asian countries (China, Philippines, Korea, Indonesia, and Japan) and in Chile. In Europe, seaweed has traditionally been collected by coastal communities on a small scale to use as fertiliser or soil-conditioner. The most common system to obtain seaweed biomass is by harvesting natural stocks in coastal areas with rocky shores and a tidal system. The natural population of seaweed is a significant resource, although the location and seasonal availability of these resources are unpredictable. The second possibility for seaweed biomass generation is through cultivation. Only a few genera have been commonly cultivated for many years. There is no consensus concerning optimum systems for microalgae cultivation. Scientists

132 'Sustainable Energy Ireland: A Review of the Potential of Marine Algae as a Source of Bio-fuel in Ireland'. 2009.

disagree over whether open or closed or some combination of cultivation systems is most favourable. Open-pond systems, such as raceways, entail low capital and operating cost, but also low productivity and lack of control over cultivation. Closed systems, such as photo-bioreactors (PBR) are much more expensive but offer higher productivity.

In existing commercial applications, artificial light and sometimes heat are used. The biggest unknown in Ireland or other similar climates is whether it is possible to achieve reasonable productivity in view of prevailing natural light and temperatures. For regions at higher latitude, it may be possible to identify local strains requiring low light intensities and lower water temperatures but giving satisfactory growth rates and yields.

Research is underway in Ireland to develop marine biomass assessment methods[133]. Hyperspectral technologies are available to monitor the intertidal zone. It is based on aerial capture - flights can cover very large zones in a short time, allowing precise maps to be quickly defined. Hyperspectral technology is commonly used to evaluate green tides, but has also been used to evaluate brown seaweed stocks.

Potential for bio-fuel sector

On average, biomass accounts for 3 to 4%of total primary energy[134] use in the developed countries, although where policies supportive of biomass use are in place, e.g. in Austria, Sweden, and Finland, the biomass contribution reaches 12, 18, and 23 percent respectively.

Bio-fuels are produced in processes that convert biomass into more useful intermediate forms of energy. There is particular interest in converting solid biomass into liquids, which have the potential to replace petroleum-based fuels used in the transportation sector. However, adapting liquid bio-fuels to our present day fuel infrastructure and engine technology has proven to be controversial.

Only oil producing plants, such as soybeans, palm oil trees and oilseeds like rapeseed can produce compounds similar to hydrocarbon petroleum products, and have been used to replace small amounts of diesel. This "biodiesel" has been marketed in Europe and to a lesser extent in the U.S., but it requires substantial subsidies to compete with diesel.

The limit so far is that the traditional markets for seaweed products sustain a much higher price for raw material than that likely for bio-fuel production.

Existing initiatives

In Europe, knowledge of seaweed cultivation is scattered across several R&D groups and a few industrial groups. The amount of cultivated seaweed is very low, mainly very small companies with local facilities for cultivating high value species.

Nonetheless, some research projects on algae based bio-fuels are emerging:

SHAMASH: The goal of the Shamash project is to produce bio-fuel from autotrophic microalgae. These organisms can accumulate fatty acids up to 50% of their dry weight. Their productivity is then 30 times higher than oil crops. The project involved seven public research teams and a private company. A wide range of specialists were associated in the project: algae culture, physiology and metabolism, process design and optimisation, bio-fuels and lipids extraction and purification, engine testing.

The SYMBIOSE project aims at developing a procedure to methanise microalgae that would allow the fixation of CO_2 and the production of methane. The project brings together teams specialized in bacteria algae, ecophysiology of microalgae, bacterial fermentation as well as process modeling.

The Breizh'Alg project was set in place to develop a strong sustainable high quality algae production industry in Brittany, to develop the synergies with the shellfish production

[133] Blight 'Development of a Methodology for the Quantitative Assessment of Ireland's Inshore Kelp Resources'. 2008.
[134] Herzog et al. 'Renewable energy sources'.

industry already in place. GreenStars is a collaborative project involving many actors in the micro algae industry in France. It aims at developing efficient bio-fuel based on microalgae and human activity outputs by 2020. Finally, the Maersk Kalmar container vessel sailed in December 2011 from Bremerhaven, Germany to Pipavav, India, burning 30 tons of fuel derived from algae. A team of engineers from Maersk Line, Limited, Maersk Maritime Technology and Maersk Line ran the project from onboard. They tested blends of the fuel in one of the ship's auxiliary engines. While the Maersk Kalmar does not sail under algae power yet - the energy produced only powered the ship's electronics-, the objective is for the main engine to also eventually run on algae fuel.
Type of data needed

Methods of obtaining global data on seaweed stocks are available. Specific sonar technologies can generate large amounts of data drawing maps identifying underwater stocks of Laminaria. But at some locations it was observed that stocks decrease in some years: **the factors involved are not yet understood**. This might lead towards the use of cultivation. But studies also point to the **lack of available data on the potential economic returns of cultivation.** Though there is a large amount of reported productivity data for a range of seaweed species worldwide, in order for this data to be used and applied to a specific context, there is a strong need for careful interpretation.
 	
In general, there is a **lack of long term trial data**. Many of the reported values are based on experimental plots, or short term trials which were not continued over an entire growing season: insufficient data and experience is available.
 	
In the case of Ireland, it is clear that the only reliable data that could be used for estimating the Irish resource and developing a business model in Ireland would be the results of grow-out trials of relevant species under low-cost cultivation conditions.[135]Many pilot studies are currently under way to develop algae cultivation, in order to have context specific information, though pilot studies take time and can be expensive. **The incentive to develop research should come through easier to access information, in order to lower research costs.**
 	
In summary, the data needed to develop research on algae based products, including bio-fuels, can be divided into 2 categories:
 	
› Data on cultivation of algae :
  › how to grow algae without consuming too much fossil energy in the process,
  › how to grow quality algae
  › how to create microalgae more suited to the needs
› Data on the location and availability of natural stocks based on prediction models and observations.

Marine knowledge 2020
Whilst there is no specific reference to cultivation of seaweed in the Marine Knowledge 2020 initiative, it is worth noting: The Energy Strategy 2020 states that the European Commission will promote energy research infrastructures including marine renewable energy, which is considered to have a great potential. The Energy Roadmap 2050 builds on the single energy market, the implementation of the energy infrastructure package and climate objectives as outlined in the 2050 low carbon economy roadmap.

135 Sustainable Energy Ireland: A Review of the Potential of Marine Algae as a Source of Bio-fuel in Ireland. 2009

Innovative services and benefits
Current/ future services to be developed
The objective of the innovative services is to create new sources of renewable energy less polluting that fossil energy. Types of services may include: › Create new algae that can be used as bio-fuel › Cultivate quality algae efficiently and at the lowest cost possible to make it competitive › Better knowledge of natural stocks seasonality and availability
Economic benefit
As seaweed is a commodity traded in the international market, **prices are subject to volatility**. This was particularly evident during the "seaweed price bubble" of 2008, when farm prices reached exorbitant levels and then collapsed in the course of a few months. The potential of having a more stable cultivation process and a bigger outlet for the utilisation of the seaweed increases the economic benefits of more seaweed based products. But given the two main potential markets that are **bioenergy and biomaterials**, the economic benefits of products based on seaweed are potentially very high. Nonetheless, it is difficult to estimate the economic benefit for potential uses at an early stage of development. They may be isolated to some niche markets in areas where demand is sufficient and algae can be cheaply produced or new uses may open up more general demand, from which European producers could benefit. <u>The Irish example</u> The Irish Sea Fisheries Board estimated the economic potential of seaweed aquaculture in Ireland, in particular with regards to energy production. The estimates produced show that up to 447 TJ of energy might be generated from macroalgae by 2020. This is about 0.2% of current national road-fuel demands[136] According to the Sea Change Strategy (2006), the Irish seaweed production and processing sector will be worth €30 million per annum by 2020.[137] Ireland's seaweed and biotechnology sector is currently worth €18 million per annum. It processes 36,000 tonnes of seaweed (wild product) and employs 185 full time equivalents In order to reach this target, there is a need to capitalise on the existing wild resource and it must necessarily expand seaweed aquaculture to augment supplies of higher value seaweeds. Seaweed aquaculture in Ireland is limited to only a small number of licensed sites at the current time.[138] Moving away from the more traditional wild species and applying aquaculture techniques to create sustainable year round supply is also key to industry development.

Data sources
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[136] A Market Analysis towards the further development of seaweed aquaculture in Ireland, Máirtín Walsh, Lucy Watson et al, BIM
[137] A Market Analysis towards the further development of Seaweed Aquaculture in Ireland, Máirtín Walsh, Lucy Watson, BIM
[138] A Market Analysis towards the further development of seaweed aquaculture in Ireland, Máirtín Walsh, Lucy Watson et al, BIM

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Input received from: Jean Paul Cadoret, director, Laboratoire de Physiologie et Biotechnologie des algues, Ifremer

Case 11: Aquatic pharmacy

Case presentation: problem definition &opportunities
Overall context
Because of the physical and chemical conditions in the marine environment, almost every class of marine organism possesses the capacity to produce a variety of molecules with unique structural features. These molecules offer an unmatched chemical diversity and structural complexity, together with a biological potency and selectivity. In recent years, the chemistry of natural products derived from marine organisms has become the focus of **a much greater research effort**. This is due in large part to the increased recognition of marine organisms as a source for bioactive compounds with pharmaceutical applications (antitumor, anti-inflammatory, analgesia, immunomodulation, allergy, and anti-viral assays). The fact that marine resources are still largely unexplored has inspired many scientists to intensify their efforts by using novel technologies to overcome the inherent problems in discovering compounds which may have potential for further development as pharmaceuticals or as functional products such as cosmetics, nutritional supplements and functional foods. Secondly, deep see organisms have unique adaptations that enable them to survive in cold, dark and highly pressurised environments. As a result of these unique environments, deep-sea species often produce chemical compounds that gained considerable attention due to their pharmaceutical and biotechnology potential. Much of this diversity is found in the macroscopic plants and animals that are adapted to all regions of the world's oceans (polar, temperate and tropical). Species diversity reaches very high densities on coral reefs, occasionally reaching densities of approximately 1000 species per square metre, particularly in the Indo-Pacific Ocean where tropical marine biodiversity reaches its peak.

The need for marine knowledge in Europe
Current knowledge
A number of clinically useful drugs, investigational drug candidates, and pharmacological tools have already resulted from marine product discovery programmes (see existing initiatives). However, despite noteworthy successes and the inherent promise of the ocean's vast biological and chemical diversity, marine biomedical potential has not yet matured into an economically significant field. The clinical and commercial development of many marine natural products languishes because only a small percentage of marine biodiversity is known (e.g. it is estimated that less than 10% of reef biodiversity is known), and only small fractions of the known species have been explored as sources of biomedical compounds, whether due to technical difficulties in exploring (see "Seabed mapping" case study) or lack of information. New research technologies such as genomics (sequencing of axenic cultures) have allowed the marine ecosystem research to progress tremendously, though those new technologies are still too expensive for many researcher groups and institutes. In fact the new sequencing machines are described to bring what has been termed disruptive technology for scientists all over Europe (meaning that the rate at which it improves exceeds the rate users can adapt to the new performance). The innovative systems developed in the United States, although very useful also for European researchers, do not provide the capacities, flexibility and a higher level of data integration framework that is needed to complement the ecosystems expertise of marine ecologists with appropriate bioinformatic approaches, finally widening the gap between technology providers and field researchers. This exploration activity should be considered an asset because of its potential to increase our knowledge base, and it should not be considered a liability, particularly in

the review of proposals incorporating genomics technologies. It is important to make certain, however, that data are publicly available, and in a useful form so that the data can be used for hypothesis-driven research. Therefore, it is important that databases be developed, maintained, and made available as research tools. Secondly, it is still important not to waste efforts on redundant research projects. To reduce the duplication of effort, the data and the databases and tools that allow the scientists to analyse and utilise the data must be maintained and made accessible.
Existing initiatives
Currently there are around 15 marine natural products in various phases of clinical development, mainly in the oncology area, with more on the way. It is now almost five decades since spongothymidine and spongouridine were isolated from the marine sponge Tethya crypta which eventually led to the development of Ara-C used against leukaemia and Ara-A for treating viral infections (FDA approval 1969/1976). However, it was not until 2004 that the next marine natural product ziconotide (PrialtR) was approved followed by trabectedin (YondelisR) in 2007, both of which were commercialised by European companies (Prialt by Elan, Ireland and Yondelis by Pharmamar, Spain). The future potential of the marine biotechnology market remains to be discovered and is attracting increasing attention in the public and private sector. The marine biotechnology sector in Europe is still in its infancy, characterised by small companies principally focused on R&D. The **European Centre for Marine Biotechnology**, for example, is a business incubator for new and emerging marine biotechnology companies in the UK. ECMB aims to be one of Europe's premier sites for marine biotechnology, by establishing a growing cluster of activity and international networks. Much of the activity in this sector is also based out of Europe's universities and research institutes. One such project, financed under FP7, it the Marine Genomis for Users (MG4U) project that brings together seven partners from across Europe. The project is based on the simple idea that marine genomics has an enormous potential to improve lives and prosperity, but many business leaders and political leaders are **not yet aware of how marine genomics hold great potential for problem solving and industrial commercial advantage**. MG4U seeks to facilitate knowledge transfer, technology transfer, and technology translation between high-throughput marine genomics, industry and society. Another unique project financed under FP6 is Aquafinder, which ran until 2011. Uncovering the marine environments unexplored potential for blue biotechnologies involves efficient exploration of inaccessible areas. Autonomous underwater vehicles (AUVs) are one technology that possess the potential to make **continuous monitoring and real-time data widely available through low-cost, large-scale, long-term robotic missions**, even in deep, toxic or otherwise inaccessible areas. However, the lack of AUV independence (AUVs do not intelligently modify their course according to their online analysis of the environmental conditions in the water). Aquafinder worked to develop a novel method for locating chemical sources: small, low-cost AUVs (Autonomous Underwater Vehicles), capable of sensing a specific chemical and autonomously navigating to where its concentration is highest, thus locating the hot spot. Bio-navigation can allow AUVs to intelligently track the odour plumes emanating from their targets and effectively navigate in chemical gradient fields to reach the source.
Type of data needed
Biotechnology companies looking for new pharmaceuticals or enzymes to catalyse industrial processes need to know where to look for the strange life forms that can live without light or withstand extremes of temperature. Bioprospecting, greater knowledge of sediments, habitats and sea-floor topography will allow those searching for products such as enzymes or pharmaceuticals to target their exploration better. Throughout Europe, researchers in the field of biodiscovery utilise a vast array of methods and protocols to obtain, extract and fractionate bioresources and interact in a

variety of ways with screening facilities. If this resource could be harnessed and utilised efficiently through the use of common protocols and procedures, it would be a powerful adjunct to Europe's pharmaceutical and functional product industry. The type of marine data that would be useful would be an **extensive taxonomy of marine organism in order to be able to create biobanks**: type, organism focus, taxonomy of organisms, amount available, format (preserved, freeze dried, chemical extract, DNA, strain) and any residual ownership/IP rights associated. Greater simplification could be attained if these facilities could agree on a common set of standards for the preparation of extracts and libraries that can be used in the majority of screening formats, as well as a common format for data exchange. This could include: the use of common extraction procedures giving drug-like purified extracts; accepted concentrations of pure compounds and assay-plate format; common presentation of data for the screening facility; common reporting format of screening data; and procedures for prioritising hits. Capability to carry out validation of hits and conduct follow-up studies to translate an intuition into a lead or products is also a necessity.
Marine knowledge 2020
Since the year 2000, the European Commission has been working with Member and Associated States towards the development of the European Research Area (ERA), one of the goals of which is to better integrate the scientific communities and the infrastructures they need to conduct interdisciplinary and collaborative research. The Networks of excellence (NoEs) funded under FP6 have contributed to this integration, including some marine-focused projects The Marine Strategy Framework Directive (2008) mentions that "marine environment is a precious heritage that must be protected, preserved and, where practicable, restored with the ultimate aim of maintaining biodiversity and providing diverse and dynamic oceans and seas which are clean, healthy and productive (...)This Directive should also support the strong position taken by the Community, in the context of the Convention on Biological Diversity, on halting biodiversity loss, ensuring the conservation and sustainable use of marine biodiversity, and on the creation of a global network of marine protected areas by 2012.". Finally, use of marine resources in the pharmaceutical industries is one of the focus of the Blue Growth strategy. "While estimated current employment in the sector in Europe is still relatively low, and a gross value added of €0.8 billion, the growth of the sector will offer high-skilled employment, especially if ground-breaking drugs can be developed from marine organisms, and significant downstream opportunities. In the very short term, the sector is expected to emerge as a niche market focused on high-value products for the health, cosmetic and industrial biomaterials sectors. By 2020, it could grow as a medium-sized market, expanding towards the production of metabolites and primary compounds (lipids, sugars, polymers, proteins) as inputs for the food, feed and chemical industries. In a third stage, around 15 years from now and subject to technological breakthroughs, the blue biotechnology sector could become a provider of mass-market products, together with a range of high added value specialized products."

Innovative services and benefits

Current/ future products to be developed

The objective is to develop marine based pharmaceuticals. Currently there are around 15 marine natural products in various phases of clinical development, mainly in the oncology area, with more on the way. Types of products may include;

- Anti-cancer drugs
- Treatments of Alzheimer's disease
- Prevention of cancer
- Tissue rebuilding

Existing/ ongoing initiatives:

While at least one-half of all therapeutic drugs on the current market are now derived from terrestrial organisms, we can expect many new drugs to be developed from marine organisms in the coming years. These drugs will be used as pharmaceuticals, nutritional supplements, biocides, cosmetics and other life-saving and life-enhancing products.[139]

Two compounds isolated from deep-sea sponges are in human clinical trials, and several other promising compounds and applications, resulting from research on deep-sea sponges and corals, are in early stages of development.

Coral reef species (e.g., algae, sponges, soft corals, sea slugs) have already been used in the development of anti-cancer and anti-tumour drugs, painkillers, and anti-inflammatory agents. Below, a table shows a few marine products that are being researched in order to develop anti-cancer drugs.

Figure 6 : Selected marine natural products in development as anticancer drugs (source European Science Foundation Marine Board, 2010)

clinical trial	name	source	target	developed by
In Clinical Use	ectenaiscidin 743 (Yondelis)	tunicate	tubulin	PharmaMar, Rinehart
phase III	E7389 (halichondrin B inspired)*	synthetic	tubulin	Eisai
phase II	dehydrodidemnin B (Aplidine)	tunicate	ornithine decarboxylase	PharmaMar, Rinehart
phase II	soblidotin (aka TZT1027, dola-10 insp.)	synthetic	tubulin	Teikoku, Pettit
phase II	synthadotin (aka ILX651, dola-15 insp.)	synthetic	tubulin	ILEX
phase II	bryostatin 1	bryozoan	PKC	GPC Biotech, Pettit
phase II	squalamine	shark	angiogenesis	Zasloff
phase II	kahalalide F	mollusk	multiple	PharmaMar, Scheuer
phase I	PM02734 (kahalalide insp.)	synthetic	solid tumor	PharmaMar
phase I	Zalypsis (jorumycin insp.)*	synthetic	DNA	PharmaMar
phase I	E7974 (hemiasterlin insp.)*	synthetic	tubulin	Eisai
phase I	taltobulin (aka HTI286, hemiasterlin insp.)*	synthetic	tubulin	Wyeth, Andersen
phase I	salinosporamide A (aka NPI0052)	bacteria	proteasome	Nereus, Fenical
phase I	spisulosine (aka ES285)	clam	Rho	PharmaMar
phase I	KRN-7000 (agelasphin insp.)*	synthetic	NKT	Koezuka-Kirin
phase I	NPI 2358 (halimide insp.)	synthetic	tubulin	Nereus, Fenical
phase I	LBH 589 (psammaplin insp.)*	synthetic	HDAC	Novartis

Economic benefit

The global market for marine-derived drugs was $US 4.8 billion in 2011 and is expected to be $US 5.3 billion in 2012. This global market is forecasted to reach $US 8.6 billion in 2016 at a compound annual growth rate of 12.5 percent for the five-year period of 2011 to 2016, according to BCC Research[140].

- The market for sponges was $US 3 billion in 2010 and is expected to reach around $US 3.2 billion in the year 2012. BCC Research has forecasted that this market will

[139] Bruckner, 2002 quoted in CORIS, NOAA's coral reef information system
[140] "Global Markets for Marine – Derived Pharmaceuticals" cited in Market Research Reports and Technical Publications Product Catalog December 2012, http://www.bccresearch.com/report/marine-derived-pharma-markets-phm101a.html

reach nearly $US 4 billion by 2016 at a compound annual growth rate of 5% for a five year period.

- According to BCC Research undertaken in 2011, mollusc is the fastest growing market for marine-derived drugs, and is expected to grow from $US 69.4 million in 2011 to $US 490.1 million by 2016 at a CAGR of 47.8%.[141]

The case of Trabectedin, ET-743 (Yondelis®) reflects both the challenges and the potential economic benefits involved

It is a unique anticancer agent that binds the minor groove of DNA. Extracts of E. turbinata were shown to have anti-tumour effects in 1969, but isolation of the active compound was not achieved until 1990. Phase I and II clinical trials were carried out using material derived from aquaculture, but this was not deemed feasible for the larger phase III trials. For this reason, an economically viable semisynthetic process was developed starting with the natural product safracin B isolated from the microorganism.

Pharmamar received approval to market Yondelis® in Europe in September 2007 for the treatment of soft tissue sarcoma and this was the first drug to be approved for this condition for more than 25 years. Centocor Ortho Biotech Products, L.P. has obtained worldwide marketing rights for Yondelis® except in Europe. In November 2009, Pharmamar won final European approval for the use of Yondelis® in the treatment of ovarian cancer.

This drug has now been approved for use in **57 countries worldwide**, of which 26 are outside Europe. Subsequent to approval for ovarian cancer, sales have increased to €17 million in the first quarter of 2010.

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[141] "Global Markets for Marine – Derived Pharmaceuticals" cited in Market Research Reports and Technical Publications Product Catalog December 2012, http://www.bccresearch.com/

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Input received from: Gilles Lericolais, Ifremer

Case 12: Protecting Biodiversity for Tomorrow's Blue Economy

Case presentation: problem definition & opportunities
Overall context
Biodiversity refers to the diverse array of ecosystems, species and genes and is the *foundation upon which marine economic and social activities depend*. Human well-being is dependent upon a multitude of "ecosystem services" provided by nature free of charge. These services include; biogeochemical cycles critical to life (nitrogen cycle, water cycle, carbon cycle, oxygen cycle...), bioremediation of pollution, pollination and even pest control. Furthermore, biodiversity represents an *inestimable economic potential for future innovation* with hundreds of thousands if not millions of organisms and bioprocesses undiscovered, which could hold the answers to big medical questions and represent billions in innovative new technologies. According to an oft cited figure, each year we lose 3% of GDP due to the loss of biodiversity, which costs the EU € 450 billion year after year[142]. This economic loss often escapes our current systems of accounting and does not figure in the policy making process. According to a recent study led by Ward Appeltans[143] of the IOC[144], the oceans may be home to one million marine species, far less than previous estimates (2 to >10 million). Yet, we have only described nearly 230,000 and documented extinctions and detailed impact and stock assessments are scarce. According to statistics published by the Convention on Biological Diversity, only 73% of the original natural global diversity was left in 2000 and this trend can be expected to continue with the anthropogenic rate of species extinction 1 000 times higher than the natural rate[145]. This means that there is an enormous information gap that limits sound, scientifically-based policy making when it comes to protecting Europe's maritime biodiversity and its future economic potential. Today, that task is becoming more and more difficult as biodiversity in Europe's seas, oceans and coastal areas faces an unprecedented array of pressures such as climate change, pollution, habitat loss and over-exploitation. Complacency in the protection of marine biodiversity could represent a loss of billions of Euros annually in what environmental scientists refer to as 'option value', or the potential benefit of natural resources not currently exploited or even discovered and decreasing biodiversity affects the health of the wider marine ecosystem, putting stress on the 'ecosystem services' that underpin the maritime economy. In order to better manage ecological security and ensure a flow of future innovation, researchers and policy makers must first be able to *better understand and measure biodiversity*. This task requires a cross-cutting, integrated approach, because of the sheer magnitude of factors that affect biodiversity. The current understanding of marine biodiversity is limited by the tools available to researchers, as well as level of cooperation and integration of existing data sources. Developing new tools and methods to measure the health of ecosystems and new modes of cooperation in order to improve the cost-effectiveness of gathering and analysing environmental data are key challenges for better policy making in Europe. Understanding and internalising the economic 'cost' of losing biodiversity will also act as a driver for better decision making. While environmental monitoring is not an economic activity in itself, it is a *conditio sine qua non* for the future sustainable exploitation of natural resources and could represent

142 http://ec.europa.eu/environment/nature/biodiversity/comm2006/2020.htm
143 http://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=10847735
144 Intergovernmental Oceanographic Commission
145 http://www.cbd.int/incentives/doc/biodiv-economic-value-en.pdf

billions of Euros annually in 'option value' as new scientific advances in sectors such as biotechnology find innovative ways of exploiting the seas resources. Nevertheless, a recent report on *Blue Growth* commissioned by DG MARE identifies the *important economic potential of maritime surveillance activities themselves for coastal areas*. This includes environmental monitoring, which is expected to increase with a doubling of turnover within the next decade (implying some annual 7% growth on average). Furthermore, the environmental surveillance capacity needed to effectively manage Europe's biological wealth can be expected to create important synergies with other research and economic activities.

Situation in Europe

Europe's marine biodiversity faces many of the same challenges experienced throughout the world. The threat is highest along Europe's coastlines where marine biodiversity is the greatest, due to the wide range of natural habitats. These threats include habitat loss, global climate change, overexploitation and other effects of overfishing and unsustainable fishing practices, non-native species introductions/invasions, pollution, eutrophication and physical alterations of coasts.

Pollution

Most marine pollution is land based (80% in Europe[146]) and comes from diffuse sources such as agricultural runoff. When pollution, such as pesticides are introduced into the marine environment they can be quickly absorbed into marine 'food webs' and affect the entire ecosystem, often through complex, unforeseen processes. According to UNESCO, excessive nutrients from sewage and agricultural runoff have contributed to the increasing incidence of low oxygen (hypoxic) areas known as dead zones, where most marine life cannot survive. There are now some 500 dead zones worldwide with a total global surface area roughly equivalent to that of the United Kingdom[147]. Excess nitrogen can contribute to the proliferation of seaweeds and microorganisms and cause algal blooms, which can cause massive fish kills, and contaminate seafood with toxins. Litter can accumulate in large 'garbage patches', release contaminants as they break down into toxic micro-particles and was up on shore.

Overfishing

Overfishing occurs when fish are being caught faster than they can reproduce and replace themselves and can directly and indirectly affect biodiversity at the ecosystem, population and genetic level. At the genetic level, fisheries change population characteristics (e.g., age distribution, re- production, stock structure), resulting in alterations to the genome. At the species level, fisheries affect species composition and interactions. Finally, through effects of by-catch, habitat alteration, and altered energy flow, fisheries impact the diversity of marine habitats and the function of ecosystems.

Non-native species

An invasive species, or non-indigenous species, is "any species whose translocation into an environment outside its native geographical habitat, within historical times, has been either man-mediated (either intentionally or accidentally) or has been an action of active dispersal via natural pathways".[148] While natural boundaries ('dispersion barriers' such as salinity, ocean currents and temperature gradients) can evolve without human intervention, most of the principal vectors for the introduction of non-native species involve human interaction. Non-indigenous species introduction has also become known as 'biological pollution', because of the consequences that species translocation can have on the local ecosystem. While ecosystems evolve slowly overtime naturally, the introduction of non-native species can create 'niche openings' that allow for non-

[146] http://ec.europa.eu/environment/water/marine/pollution.htm
[147] http://www.unesco.org/new/en/natural-sciences/ioc-oceans/priority-areas/rio-20-ocean/blueprint-for-the-future-we-want/marine-pollution/
[148] Streftaris, Zenetos & Papathanassiou, (2005), "Globalisation in Marine Ecosystems: The Story of Non-indigenous Marine Species across European Seas"

indigenous species to establish themselves (although not all translocated species can become 'established' in new environments. There are a multitude of means by which non-indigenous species can seriously disrupt local ecosystems. The most common consequences are; predation, mixing of exotic genes, competition, habitat modification and the introduction of non-native pathogens. In Europe, the Mediterranean has been the most heavily impacted, while the Atlantic area counts 151 non-indigenous established species[149]. In addition to impacts on biodiversity, non-native species can cause sizable economic damage. Non-native species on land and sea have been estimated to cause some €12.5 billion worth of damage each year in the EU[150].

The need for marine knowledge in Europe

Current knowledge

Current data regarding biodiversity and the various indicators concerning the threats to biodiversity are patchy and inconsistent. Due to the many drivers behind evolutions in biodiversity, a comprehensive set of data is needed on a wide range of phenomena, from chemical pollution to non-native species, in order to get a clear picture of the health of Europe's marine ecosystems. Indicators to measure biodiversity in a cost-effective and relatively accurate manner also need to be validated and further developed. However, as only a fraction of marine biodiversity has been documented and explored, much of the biodiversity loss goes by unaccounted for by researchers.

A 'global' picture of biodiversity on the European level has been slow to manifest itself. The EU has played a key role in enabling the European scientific community to take stock of biodiversity in Europe and provide policy makers with a clearer picture of current trends. Much of the task consists of developing indicators and integrating large amounts of data from many different sources in a cost-effective way. The recent paradigm shift to an 'ecosystem approach' can also be expected to contribute to generate more indicators that will be valuable to understanding biodiversity. There has been a growing realisation that fisheries management has been too myopic with its focus on maximizing the catch of a single target species while generally ignoring other important variables such as, predators and prey of the target species and other ecosystem components and interactions. The ecosystem approach provides the framework for a more effective and holistic management approach to fisheries management.

Existing initiatives

Policy framework
Over the past two decades, biodiversity has attracted increasing amounts of political attention. In 1992 the United Nations adopted the Convention on Biological Diversity (CBD), which has since been signed by over 150 countries. More recently, at the meeting of the environment ministers of the G8 countries and five additional emerging countries that took place in Potsdam in March 2007, the German government proposed a study on 'The economic significance of the global loss of biological diversity' as part of the so-called 'Potsdam Initiative' for biodiversity.

On the EU level, the new EU biodiversity strategy for 2020 was adopted in April 2012, as a follow-up to the Commission's ambitious communication 'Our life insurance, our natural capital: an EU biodiversity strategy to 2020'. In particular, the Council placed emphasis on the need to integrate biodiversity concerns into all EU and national sectoral policies, in order to establish a comprehensive approach to halt the continuing trends of loss of biodiversity and ecosystem degradation. The 2020 Strategy builds on the 2006 Biodiversity Action Plan and sets out six ambitious targets, ranging from better management of fish stocks to tighter controls on alien invasive species.

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[149] Overview of introduced aquatic species in European navigational and adjacent water ways (Gollasch, 2006)
[150] COM(2011) 244 final

The Marine Strategic Framework Directive (MSFD), which aims to achieve good environmental status of Europe's maritime waters by 2020, will also contribute substantially to the principal objectives of biodiversity initiatives, protecting the resource base upon which marine-related social and economic activities depend. The MSFD was given the objective of supporting the strong position taken by the Community, in the context of the Convention on Biological Diversity, on halting biodiversity loss, ensuring the conservation and sustainable use of marine biodiversity, and on the creation of a global network of marine protected areas by 2012.

Species and genome registries

A number of projects are aiming to establish comprehensive registries of marine biodiversity. The foundation of biodiversity research has been correctly identifying and naming species.

- MGE, Marine Genomic Europe, a project funded under FP6, brought together 44 institutions from 16 countries in and outside Europe with the aim of promoting, developing and spreading throughout the European Union a broad range of genomic approaches, to investigate a wide range of questions related to the functioning of marine ecosystems and to the biology of marine organisms. MGE has established databases of marine resources through large scale biodiversity studies.
- The Mediterranean hAlieutic Resources Evaluation and Advice (MAREA) project, launched in 2009, set out to collect long-term data sets on marine benthic communities in order to provide baselines to verify trends in the structure and dynamics of marine communities. The data then served as the foundation for the analysis of structure and dynamics of benthic communities over long-term periods by analysing demographic traits of representative species and applying landscape ecology. With the scientific knowledge gained, it is hoped to better understand and predict trajectories of benthic littoral communities at different temporal and spatial scales driven by global warming and contribute to better inform and advice strategies for biological conservation.
- BIOGAP, Biodiversity and genetics of algal populations, is a project bringing together expertise in population genetics, demography, molecular biology of algae, evolutionary biology, biogeography, phycology, and modelling that focused on the development of specific testable models for gene flow and demography in benthic macro-algae, through the coupling of matrix modelling and gene flow. This work contributed to both theoretical and empirical models from which meaningful projections about ecosystem stability/resilience and the maintenance of biodiversity can be made. Algal species were chosen that represented the principal range of seaweed life histories and that are of significant ecological importance along the European coastlines.

Greater integration of data

EU funded data platforms, such as EMODNet, are playing a role in centralising and integrating data. EMODNet in particular, is the European node of Obis, which is a global network of nodes that centralises and integrates biodiversity data, such as population statistics and environmental parameters such as salinity, temperature and oxygen levels.

Developing new indicators

Another area of research activity is the development of new indicators to assess biodiversity.

In 2012, scientists from 16 countries kicked off a new four year EU-funded project that aims to explore marine biodiversity and the environmental status of seas in Europe, DEVOTES ('Development of innovative tools for understanding marine biodiversity and assessing good environmental status'). The project seeks to improve our understanding of the impacts of human activities (cumulative, synergistic) and variations due to climate change on marine biodiversity. More concretely, a major goal is to assess and test the indicators that have already been proposed by the Commission, as well as develop new ones to monitor at the species, habitats and ecosystems level. Eventually, indicators will be integrated into a unified assessment of biodiversity and can be used notably for status classification of marine waters. Ultimately, the DEVOTES project will be able to produce the hard information that Member States need in order to effectively follow through on key actions for conserving marine biodiversity.

Creating networks of excellence

Funding has also facilitated the creation of networks of expertise, which bring specialists together from marine institutes across Europe have proven to be the foundation for more ambitious cooperation. MarBEF is a 'network of excellence' funded by the European Union that brings together 94 marine institutes from across Europe and serves as a platform to integrate and disseminate knowledge on marine biodiversity and creates links between researchers industry, stakeholders and the general public. One of the principal goals of MarBEF has been to integrate data from different sources related to marine biodiversity.

Marine knowledge 2020

The Commission's communication on Marine Knowledge 2020[151] highlighted the fact that marine knowledge is essential to the achievement of good environmental status of marine waters. Furthermore, the objectives set out in the communication call for strengthened marine scientific research, reducing uncertainty in knowledge of the oceans and improving the overall quality of public decision making at all levels by providing a sounder scientific base for policy makers. As the Green Paper mentioned, an accurate and reliable record of biodiversity trends will be essential to the formulation of effective policy in the future. With a coherent and accurate record of biodiversity trends, scientists will be able to better understand the behaviour of the underlying processes at work.

Marine 2020 can provide *critical high-level support to existing initiatives*, acting as a unifying framework for all ongoing activities on marine observation within the EU, through promoting the use of common standards and the alignment of data policies, taking into account the data needs of research being conducted to better understand and protect biodiversity. While funding is helping to develop new indicators and data platforms, one frustration is that there is relatively little funding for actual data collection efforts. As Member State budgets are further strained by the crisis, effective utilisation and integration of existing data collection will become increasingly important. Furthermore, as biodiversity is ultimately an environmental concern with an inherent global dimension, Marine Knowledge 2020 can help to ensure that EU efforts are complementary with and contribute towards an interoperable global marine knowledge system. Ultimately, scientific-based policy cannot be based on fragmented regional data. An integrated, international data system is essential for the articulation of effective and coherent environmental policies.

Innovative services and benefits

Current/ future services to be developed

Marine ecosystems provide a number of 'ecoservices' that are essential to life. While these services are ultimately the most important benefit of healthy and diverse ecosystems, their value is unquantifiable. While keeping this in mind, it can be useful to look at a few more tangible examples of how more effective management of biodiversity can contribute to wealth creation and innovation in the medium and long-term. Innovative new services that depend on the protection of biodiversity include;

- Discoveries in blue biotechnology
- Development of tourism around biodiversity

Biodiversity and biotechnology

'Blue biotechnology' involves the use of living organisms and bioprocesses from the sea, in engineering, technology and other fields requiring bio products. Blue biotechnology and algae growing in particular are expected to enter the mainstream by the year 2030.

[151] COM(2010) 46 final

A 2011 report by Global Industry Analysts put the global market for blue biotechnology $US 4.1 billion by the year 2015[152]. Key factors driving market growth include growing interest from medical, pharmaceutical, aquaculture, nutraceutical and industrial sectors. Approximately half of synthetic drugs have a natural origin, including 10 of the 25 highest selling drugs in the United States of America[153]. Of all the anti-cancer drugs available, 42% are natural and 34% semi-natural[154]. Future discoveries in this sector will depend heavily upon knowledge about and protection of biodiversity. The Commission's Green Paper on Marine Knowledge 2020 remarks that *biotechnology companies looking for new pharmaceuticals or enzymes to catalyse industrial processes need to know where to look for the strange life forms that can live without light or withstand extremes of temperature*.

<u>Biodiversity and ecotourism</u>

Tourism is the single largest maritime activity in Europe, employing over 2 million individuals growth rates of 2 – 3% expected in the coming years[155]. An increasing demand for unique experiences will play a key factor in the evolution of this market, particularly up-scale segments. Ecotourism is a growing form of niche tourism that involves visiting pristine, relatively undisturbed natural areas. Protecting biodiversity and promoting ecotourism can be mutually reinforcing as one of the most effective ways of tackling the challenges to marine biodiversity is creating protected areas on Europe's coastlines, which can in turn encourage tourism in the area. Specifically, popular coastal tourism activities such as fishing and nature excursions may be threatened by the decline of local species.

Economic benefit

While assigning economic value to ecosystem and biodiversity may seem reductive, the exercise can provide a sense of what Europeans stands to lose from future changes in biodiversity, although it glosses over ethical considerations such as the intrinsic or 'non-use' value of natural resources.

<u>Ecosystem services</u>

According to one oft cited figure, each year Europe loses 3% of GDP due to the loss of biodiversity, which costs the EU 450 billion Euros year after year. Much of this is due to essential ecosystem services for which biodiversity is essential.

› Natural fisheries management: biodiversity affects the capacity of living systems to respond to changes in the environment, and is essential for providing goods and services from ecosystems. A high diversity within a population or ecosystem helps protect it against environmental stressors (e. g., climate change, pollutants) and the spread of diseases. The loss of genetic diversity weakens a population's ability to adapt, the loss of species diversity weakens a community's ability to adapt and the loss of functional diversity (the variety of biological processes characteristic of a particular ecosystem) weakens an ecosystem's ability to adapt. With increasing pressures on marine environments, this diversity can contribute significantly in the long run to the sustainability of Europe's fisheries;

› Flood/storm protection: ecosystems can buffer humans from natural hazards such as floods and storms. A study conducted by the New Jersey Department of Environmental Protection found that the State's wetlands were the most significant ecosystem service provider (almost 50%), representing annual services of $US 9.4 billion for freshwater wetlands and $US 1.4 billion for saltwater wetlands. The most

[152] http://www.prweb.com/releases/marine_biotechnology/marine_biomaterials/prweb 9420116.htm
[153] http://www.cbd.int/incentives/doc/biodiv-economic-value-en.pdf
[154] http://www.minambiente.it/export/sites/default/archivio/biblioteca/protezione_natura/dpn_brief_guide_national_biodiversity_strategy.pdf
[155] *Blue Growth* DG MARE, 2011

important services provided by wetlands were disturbance regulation ($US 3 billion), water filtration ($US 2.4 billion) and waste treatment ($US 1 billion);[156]

- Atmospheric and climate regulation: marine ecosystems affect and are affected by atmospheric and climate conditions
- Cultural services: non-material benefits gained from ecosystems. A study conducted by the New Jersey Department of Environmental Protection found that the State's beaches provided $US 116 million per year in aesthetic and recreational amenities.[157]

Option value and biodiversity
The valuation of biodiversity change is complicated by the uncertainty in the future uses of natural resources, and irreversibility when they are lost. The preservation of the stock of a natural resource has a value in addition to its current use-value (if it is commercially exploited), which is the value of extending society's set of future options. Future options have an additional worth because, with the passage of time, humans can be expected to ascertain more information about the potential uses of those resources. Environmental economists call this additional worth the 'option-value'. Thus, preventing the loss of the possibility of future exploitation of natural resources preserves an 'option value' for society.

Undiscovered species under threat of extinction, while they may have little economic 'use value' can hold astronomical 'option value' in that they may hold keys to future scientific advancement. For example, significant value ($US 230–330 million) has been attributed to genetic information gained from preventing land conversion in Jalisco, Mexico, in an area containing a wild grass, teosinte (Euchlaena mexicana), that can be used to develop viral-resistant strains of perennial corn[158]. Without the specification of future function that will connect species to directly valued goods and services or ecosystem services they produce, it is impossible to provide an estimated option value. A more ambitious 1997 study from the United States estimated that the annual economic and environmental benefits of biodiversity in the United States total approximately $US 300 billion and a 2009 study by Gallai et al. found that insect pollination in the EU has an estimated economic value of € 15 billion per year[159].

Data sources

European Environmental Agency

http://ec.europa.eu/environment/nature/biodiversity/comm2006/2020.htm

http://ec.europa.eu/environment/water/marine/pollution.htm

http://ec.europa.eu/environment/nature/biodiversity/comm2006/2020.htm

http://ec.europa.eu/environment/nature/biodiversity/economics/index_en.htm

Commission Documents

COM(2011) 244 final

COM(2010) 46 final

Directive 2008/56/EC

COM(2012) 473 final

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[156] Costanza, Wilson, Troy, Voinov, Liu & Agostino 'The Value of New Jersey's Ecosystem Services and Natural Capital'. 2006.
[157] Costanza, Wilson, Troy, Voinov, Liu & Agostino 'The Value of New Jersey's Ecosystem Services and Natural Capital'. 2006.
[158] Fisher, A. C. & Hanemann, W. M. Option value and the extinction of species. Adv. Appl. Micro-Econ.4, 169–190 (1986)
[159] Gallai et al, 2009

IOC Report on Biodiversity http://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=10847735 Convention on Biological diversity http://www.cbd.int/incentives/doc/biodiv-economic-value-en.pdf UNESCO facts and figures on Marine Pollution http://www.unesco.org/new/en/natural-sciences/ioc-oceans/priority-areas/rio-20-ocean/blueprint-for-the-future-we-want/marine-pollution/ Boehlert 'Biodiversity and the Sustainability of Marine Fisheries' http://www.ncbi.nlm.nih.gov/pubmed/19965343 Streftaris, Zenetos & Papathanassiou, (2005), "Globalisation in Marine Ecosystems: The Story of Non-indigenous Marine Species across European Seas" http://nobanis.slu.se/.../Streftaris%20et%20al%202005.pdf The Economics of Ecosystems and Biodiversity - Interim Report 2008 http://ec.europa.eu/environment/nature/biodiversity/economics/pdf/teeb_report.pdf Overview of introduced aquatic species in European navigational and adjacent water ways (Gollasch, 2006) www.vliz.be/imisdocs/publications/100492.pdf Global Industry Analyst Marine Biotechnology Market Forecast http://www.prweb.com/releases/marine_biotechnology/marine_biomaterials/prweb9420116.htm Brief Guide to National Biodiversity Strategy http://www.minambiente.it/export/sites/default/archivio/biblioteca/protezione_natura/dpn_brief_guide_national_biodiversity_strategy.pdf Blue Growth DG MARE, 2011 http://ec.europa.eu/maritimeaffairs/documentation/studies/documents/blue_growth_third_interim_report_en.pdf
Input received from : Ward Appeltans, UNESCO - IOC

6.5.5 Other sectors

Case 13: Seabed mapping mitigate risks of seabed mining

Case presentation: problem definition & opportunities

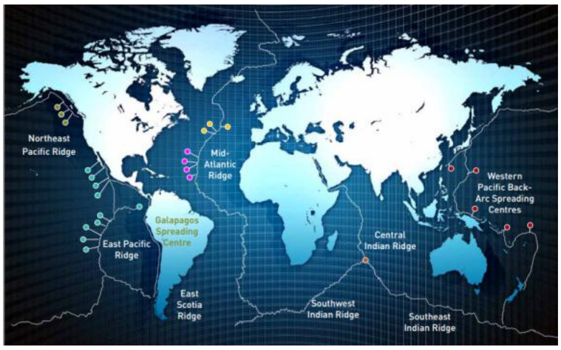
Overall context

The ocean floors hold an abundance potential mineral wealth. Deep-sea hydrothermal vent systems attract considerable interest from commercial mining companies: vent systems precipitate seafloor massive sulfide (SMS) deposits that are rich in copper, gold, silver, and zinc. Although commercial firms are targeting inactive SMS deposits, these deposits are so little studied that it is unknown whether they harbour unique species or ecosystems.

The international seabed area covers more than 50% of the world's surface. It includes all the seabed areas beyond the 200-mile-limit exclusive economic zones of every country around the world. The ocean floor is so far a largely unexploited resource, due to technical, environmental and political constraints. At the present time, the world's oceans have low levels of representation in protected areas, with only approximately 0.6% of the oceans and 6% of territorial seas protected. These protected areas cover only a small percentage of the different habitats within the marine domain. With few recent exceptions, marine protected areas are heavily concentrated along continental coastlines, providing relatively little protection to deep sea and open ocean habitats such as seamounts (~2% of total protected[160]). In comparison, many coastal habitats, such as mangroves (~17% of total protected[161]) are relatively better represented in global protected areas systems.

Mineral-related activities are highly diverse. Prospecting may target polymetallic nodule deposits and sulphides on the ocean floor or minerals embedded in cobalt-rich crusts. Mining may take place in depths of up to 6,000 metres and along biologically rich ocean floor areas, such as seamounts and hydrothermal vents.

Figure 7: Location of hydrothermal systems and polymetallic sulphide deposits.



Source : Out of our depth, Mining the Ocean Floor in Papua New Guinea, Helen Rosenbaum, 2011

The location of hydrothermal systems and polymetallic sulphide deposits is mostly situated at the junction of the 9 tectonic plaques around the world, which means most are in international waters. That is the main reason that the International Seabed Authority is the principal player in most discussions and research on the topic.

But there is a high level of uncertainty about the risks posed by deep sea mining

[160] Global Open Oceans and Deeps Seabeds biogeographic classification, Marjo Vierros, Ian Cresswell, Elva Escobar Briones, Jake Rice, Jeff Ardron, UNESCO 2009
[161] Global Open Oceans and Deeps Seabeds biogeographic classification, Marjo Vierros, Ian Cresswell, Elva Escobar Briones, Jake Rice, Jeff Ardron, UNESCO 2009

to marine environments and to communities. What is certain is that impacts will be associated with each step of the mining process. Therefore, deep sea mining is heavily regulated and subject to licensing.

The first commercial deep sea mining operation was agreed on by the government of Papua New Guinea in 2008, though the actual mining has yet to start. Canadian mining company Nautilus Minerals Inc. (Nautilus) with the mining project, known as the Solwara 1 project, will extract gold and copper from the floor of the Bismarck Sea in Papua New Guinea.[162]

The need for marine knowledge in Europe

Current knowledge

The new frontier of deep-sea exploration and mining raises a number of questions about the sustainable use of these resources and potential environmental impacts. There is very little knowledge about the marine biodiversity on the ocean floor.

Technologies to effectively map the seabed are just emerging, are expensive, and are changing and improving rapidly.

The EMODnet Hydrography portal provides hydrographic data collated for a number of sea regions in Europe:

- the Greater North Sea, including the Kattegat and stretches of water such as Fair Isle, Cromarty, Forth, Forties, Dover, Wight, and Portland
- the English Channel and Celtic Seas
- Western Mediterranean, the Ionian Sea and the Central Mediterranean Sea
- Iberian Coast and Bay of Biscay (Atlantic Ocean)
- Adriatic Sea (Mediterranean)
- Aegean - Levantine Sea (Mediterranean).

The portal development was initiated in June 2009 and the provision of bathymetric data products has been available to users since June 2010. Construction of a (1/8′) gridded digital terrain model covering all European waters has started and will be available in 2014. Lower resolution data from sources such as GEBCO will fill in the areas where higher resolution survey data are not available.

The International Hydrographic Organisation is currently working on the Marine dimension of Spatial Data infrastructures (the relevant base collection of technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data).

Existing initiatives

There are 2 major projects led by the International Seabed Authority intent on enhancing our understanding of the deep sea biodiversity.

Kaplan project: Analyzing Biodiversity, Species Ranges and Gene Flow in Nodule Areas of the Seabed

- Before the project, there was very limited knowledge of the **number of species** residing within the nodule-rich areas and the typical geographic ranges of these species. This made it extremely difficult to predict the threat of nodule mining to biodiversity and, in particular, the likelihood of species extinctions within areas that

[162] Out of our depth, Mining the Ocean Floor in Papua New Guinea, Helen Rosenbaum, 2011

would potentially be perturbed by single mining operations.

- This project was a successful attempt to analyze species composition and rates of gene flow of living organisms across the abyssal plains of the Clarion-Clipperton Zone in the Central Pacific Ocean. The Kaplan Project is also an excellent example of how collaborative marine scientific research is being used by the International Seabed Authority to minimize the risks of mining activities to deep-sea biodiversity in this Zone. Scientists set out to evaluate the biodiversity of three key faunal groups by determining levels of species overlap in sample areas and estimating numbers of species at 'stations' spaced out over areas across the CCZ. The sample groups represented a broad range of ecological and life-history faunal types and, combined, they constituted a high percentage of species abundance and richness in abyssal sediments.

CenSeam: Assessing Biodiversity Patterns on Seamounts to Identify Knowledge Gaps

- The International Seabed Authority partnered with CenSeam (Census of Marine Life on Seamounts, which is part of the Census of Marine Life programme) to assess the patterns of biodiversity on seamounts and the factors that determine these patterns, in order to identify the gaps in current knowledge and encourage collaborative research initiatives that will address them.
- Seamounts are undersea mountains, often of volcanic origin, that feature prominently in the world's underwater topography. Seamounts may be hotspots of biodiversity and play an important role in patterns of marine biogeography. Often highly productive ecosystems for fish, marine mammals and seabirds, seamounts are also of potential interest for deep-seabed mining. The long-term effects of prospecting and potential impacts of mining, however, are vastly understudied. The number of seamounts over 1 kilometre high has been estimated at more than 100,000 and there are many more with smaller elevation. Relatively few seamounts have been studied; about 350 have been sampled, and less than 200 of these have been sampled in any detail. As a result, the biodiversity of most seamounts on a global scale is poorly known.

Type of data needed

Current biogeographic theory suffers from limited understanding of open ocean and deep sea ecosystems, as well as from a lack of knowledge about the vulnerability, resilience and functioning of marine biodiversity in these areas. Most marine scientific research activities have been conducted in shallow coastal waters where biodiversity is far more accessible than in remote deep sea environments, which require specialized technology and equipment to access.

Recent scientific advances based on research carried out in the context of Census of Marine Life and other ongoing programmes have provided clear evidence of the links between marine biodiversity and the functioning and provision of goods and services by the marine environment in deep sea areas[163].

However, further basic research on 'what lives where' and what affects the patchy nature of deep sea biotic distributions is needed to advance our understanding of this unexplored marine diversity and its associated biogeographic classifications. This information will also provide for an assessment of human activities in these remote areas.

There is a recognised need to:

- Improve the consistency and validation of data.
- Improve the scientific basis for biogeographic classification by encouraging **research into hydrography and species distribution** in order to provide for improved delineation of provinces, especially at bathyal depths, integrating the vulnerability and resilience of open ocean and deep seabed biodiversity to classification analysis, developing analytical strategies to delineate blurred boundaries and developing

[163] Danovaro et al, 2008

strategies to analyse nested systems (from finer-scale classifications to regional scales).

- Ensure **continued knowledge-gathering** and scientific understanding of the ecology, processes and dynamics associated with open ocean and deep sea ecosystems **in areas beyond national jurisdiction** in order to assist the management and conservation of biodiversity beyond national jurisdiction and create an understanding of the services provided by this biodiversity for the benefit to humankind and in the regulation of the planet's biogeochemical processes.
- **Develop major networking projects** that help **collate and update geo-referenced datasets**, promote the growth of taxonomic expertise, and facilitate the integration of biodiversity data and independent datasets.
- Share and disseminate the results of research and provide, as a priority, for scientific information- sharing related to open ocean deep sea biodiversity and resources (actual and potential), as well as the services provided by biodiversity.

Marine knowledge 2020

The Marine knowledge 2020 initiative includes a flagship project to prepare a seamless multi-resolution digital seabed map of European waters by 2020:

"It should be of the highest resolution possible, covering topography, geology, habitats and ecosystems. It should be accompanied by access to timely observations and information on the present and past physical, chemical and biological state of the overlying water column, by associated data on human activities, by their impact on the sea and by oceanographic forecasts. All this should be easily accessible, interoperable and free of restrictions on use. It should be nourished by a sustainable process that progressively improves its fitness for purpose and helps Member States maximise the potential of their marine observation, sampling and surveying programmes."

"However, working at this new frontier will inevitably be costlier and riskier than operating on land if each offshore facility needs to construct its own ancillary services such as cabling or supply networks. Or if all are obliged to carry out separate surveys of the sea bottom, to measure tide and currents, assess marine life that might be disturbed by their activity and monitor risks from tsunamis, storms or unfriendly marine life.

For instance, aquaculture operators need warnings of approaching toxic algal blooms or jellyfish invasions. Mining companies need to know the topography and geology of the seafloor. Biotechnology companies looking for new pharmaceuticals or enzymes to catalyse industrial processes need to know where to look for the strange life forms that can live without light or withstand extremes of temperature."

Innovative services and benefits

Current/ future services to be developed

The objective is to develop our understanding of the seafloor ecosystem to reduce the risks of seabed mining and potentially develop commercial deep sea mining. Types of services may include sharing information platforms on a European level to help develop our understanding of the marine biodiversity present in each of the European basins.

The development of commercial deep sea mining would be possible with both technological and legal breakthrough that will help determine and issue licences to private and/or public companies.

Our understanding of the seafloor ecosystem needs to be developed before the commercial deep sea mining is developed in a larger scale, through publications, and research on more accessible data collected through time and space.

Economic benefit

So far, without more information, the risks and costs of deep sea mining far outweigh the potential economic benefits. As an example:

- Although there is a glut of copper, the demand in copper worldwide does not justify the investment: in 2008, the industry produced 360,000 tonnes of copper that turned out to be unwanted.[164]
- Many land-based deposits still remain to be exploited. *Anglo-American* alone produces on land as much copper as the likely output of 100 massive-sulphide mines.
- The risks of working in a place where volcanic activity seems to have stopped but may suddenly resume are uncertain.

Regarding the Solwara 1 deep-sea mining project in Papua New Guinea, which was due to commence in 2014, it is estimated that it would bring in more than $US 140 million to Papua New Guinea's economy in its first two years of operation and claim that about 70 per cent of the project's staff would come from the country. [165] However there are concerns it will result in the destruction of a still unexplored ecosystem.

Data sources

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http://www.whoi.edu/workshops/deepseamining/

http://www.mineweb.com/mineweb/view/mineweb/en/page72068?oid=118124&sn=Detail&pid=102055

Input received from:

Yves GUILLAM and Yves-Henri RENHAS, Service Hydrographique et océanographique de la marine (SHOM)

[164] The unplumbed riches of the deep, the Economist, 2009
[165] Sarmiento, P. "Should deep-sea mining go ahead in Papua New Guinea?", January 2013

Case 14: Data to optimise offshore wind energy yield

Case presentation: problem definition & opportunities

Overall context

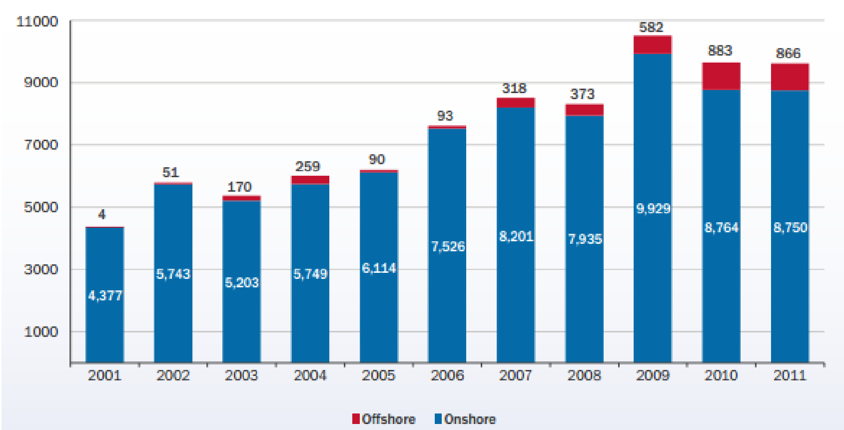
Wind energy currently meets 5.3% of the EU's electricity consumption from an installed capacity of 84.3 GW.[166] But scientists foresee a lot of potential in this alternative energy source. Offshore wind can play an important role in the transition to more sustainable energy systems, and it is critical to be able to predict the interaction between wind farms in order to optimise production. Levels of production of wind energy can be difficult to predict as they rely on potentially unstable weather conditions present at the wind farm.

Interaction between wind farms: the wind flow pattern downwind of a wind farm will influence neighbouring farms, therefore the size and location of offshore wind farms are of great importance. On a smaller scale, individual turbines will also influence neighbouring turbines (wake effect). Consequently, predicting the interaction between wind farms and turbines is important for optimizing wind energy production for large installations offshore.

Absence of electrical transmission systems at sea and in Member States' hinders the potential of offshore energy: a lack of experience with integrated spatial planning in the marine environment may lead to certain projects being abandoned. Moreover, the potential synergies between offshore projects and cross-border inter-connectors of regional electricity markets are currently not being exploited.

Wind turbines produce intermittent power because the direction and strength of the wind varies; therefore scientists are trying to generate more or less consistent power from offshore winds. They are of the view that production of energy can be more consistent if project locations can be chosen by observing regional weather patterns. They are also proposing to connect the wind power generators with a shared power line.

Figure 8 :Annual onshore and offshore installations in MW



Source: Wind in power, 2011 European statistics, EWEA

The European Commission anticipated, in its 2008 Communication on offshore wind energy[167] that "offshore wind can and must make a substantial contribution to meeting

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[166] EWEA, Pure Power, Wind energy targets for 2020 and 2030, 2011
[167] EC COM/2008/0768 final, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - Offshore Wind Energy: Action needed to deliver on the Energy Policy Objectives for 2020 and beyond

the EU's energy policy objectives through a very significant increase - in the order of 30-40 times by 2020 and 100 times by 2030 - in installed capacity compared to today."

The need for marine knowledge in Europe
Current knowledge
The current knowledge gaps lead to an underestimation of energy yield. As accurate meteorological measurements and wind energy maps become more commonly available, wind project developers are able to more reliably assess the long-term economic performance of wind farms. However, current techniques must be improved so that, given the geographic coordinates of any wind farm (flat terrain, complex terrain or offshore; in a region covered by extensive data sets or largely unknown), predictions with an uncertainty of less than 3% can be made.
Existing initiatives
The European Energy Research Alliance project “Design tools for offshore windfarm clusters” (EERA-DTOC)[168], part of the 7th Framework Programme, seeks to combine expertise in a common integrated software tool for the optimized design of offshore wind farms and wind farm clusters acting as wind power plants. To decrease uncertainties around wind farm wake predictions a small measurement campaign together with **new data available from the industry partners will enable better tuning and ultimately better modelling of the far-reaching field of wind farm wakes.** Another example of an FP7 project is led by 3E[169], and focuses on developing a “Toolbox for Offshore Wind Farm Cluster Design”. The project is running from 2011 to 2016, and will combine different design optimisation tools such as advanced wake models, turbine load models, grid interconnection models and by incorporating the operation of the offshore clusters as a virtual offshore power plant. TPWind is working on some specific R&D priorities in order to implement its 2030 vision for the wind energy sector. Specific objectives are to increase the availability of data sets from large wind farms, improve models to predict the observed power losses from wakes, and evaluate the downwind impacts of large wind farms, especially offshore. There is also work on offshore meteorology in order to improve the knowledge and understanding of processes in offshore conditions. There are also research projects that specifically look into developing prediction tools for offshore wind energy generation. One of these projects is undertaken by IRIS, the International Research Institute of Stavanger involving Statoil (Norway), Mälardalen university (Sweden), Aalborg university (Denmark), StormGeo AS (Norway), WindSim AS (Norway). The project aims to develop prediction tools for offshore wind energy production in order to make wind power production more reliable and efficient in the future. The tools developed will be used for individual farms, but given an extensive development of offshore sites the wind pattern from one farm can severely influence the potential to capture the wind energy at neighbouring wind farms within the same wind farm cluster. Using the best available computational resources, the prediction tools will address this issue.
Type of data needed
Offshore wind systems can be split into five major technology sub-areas:

[168] http://www.ewea.org/annual2012/conference/project-workshops/eera-design-tools-for-offshore-wind-farm-clusters/
[169] http://cordis.europa.eu/search/index.cfm?fuseaction=proj.document&PJ_RCN=12443338

- the turbine and their integration into arrays,
- foundations,
- collection & transmission,
- installation and operation,
- maintenance.

For each of these sub-areas, there is a need for more information. Data is needed on:

- The behaviour of existing structures in order to support further research into the development of improved design tools
- The most efficient location for offshore windfarms: meteorology, topology, quality of water, risk of extreme weather phenomena, etc..
- The impact the windfarm produces on the ambient flow in its immediate environs
- The impact of neighbouring windfarms upon each other
- How to lessen the variability of the wind power produced and to improve the ability to trade electricity (European grid to transmit the output of the wind farms).
- Infrastructure design in extreme environments
- Improve maritime spatial planning: to give the industry long-term visibility and allow forward planning. .

To estimate the energy production of a wind farm, developers must consider the following tasks:

- Wind data collection and analysis
- Wind flow modelling
- Wind resource assessment
- Energy and wake modelling
- Loss assessment
- Uncertainty analysis
- Energy assessment

Due to the lack of long-term, off-site measurements and the short duration of on-site observations, several weather simulation techniques have been developed, including mesoscale and microscale modelling. For wind assessment, developers lately use numerical weather prediction models which provide detailed atmospheric simulations of site conditions, offering long term (10-50 years) wind estimates. Insight into very high resolution wind flow behaviour can be gained with the WaSP and CFD models.

To calculate the net energy production of a wind farm, the possible loss factors have been divided into seven categories: wake effects, non-availability, electrical, environmental, wind turbine performance, curtailment and other. Not all losses may apply to a given offshore wind farm.

Marine knowledge 2020

"Marine industries will certainly benefit from the measures outlined in this paper, but there is potential for increasing these benefits by encouraging the engagement of the private sector.

According to a 2009 study, more marine data is collected by European companies than by the public sector. If a private company collects data for its own purposes then, in principle, there is no reason for public authorities to intervene or interfere. European legislation on access and re-use of these data does not apply. However, private companies are already obliged to collect data as part of the impact assessment they have to carry out to obtain a licence for certain offshore activity.

They may also be obliged to continue monitoring once operations start. In many cases, they are obliged to hand the data collected over to the licensing authority. However, once the licence has been granted, there is no apparent competitive disadvantage in releasing these data into the public domain."

The European Strategic Energy Technology Plan (SET plan), adopted in 2008, constitutes the basic framework which will make it possible to meet the main technological challenges facing this sector by 2020. That plan identifies doubling the production of offshore wind farms as one of the key challenges for meeting the 2020 targets. This will make it possible to maintain the Union's dominant position in the area of wind farm technology. One of the most ambitious projects in this area is the Dogger bank development, with a target capacity of 9 GW.

Innovative services and benefits

Current/ future services to be developed

The objective of the products / services is to:

- Increase the productivity and the energy yield of wind farms
- Decrease Europe energetic dependency towards fossil fuel

Types of products / services may include:

- Software to predict output of windfarms and optimize site selection
- Turbines that can be installed closer to one another
- Other kind of offshore installations

Economic benefit

A better assessment of energy yield will have a positive impact on the investment case, resulting in more confidence in project financing, reduction in cost through optimisation of site selection, and increase in potential production.

Innovation opportunities over the next 10 years can bring down the deployment costs of offshore wind by up to ~25%, with further savings after 2020 likely to bring down costs even further (up to circa 60% by 2050).[170]

With innovation, the hope is that the yield will increase and the capital expenditure will decrease: the innovation can be in the area of the turbine, the foundation, the collection and transmission of the electricity produced, the installation of the windfarms and the operation and maintenance.

There is enough wind around Europe's coasts to power Europe seven times over.

EWEA has a target of 40 GW of offshore wind in the EU by 2020, implying an average annual market growth of 28% over the coming 12 years. For 2010, EWEA expects the completion of 1,000 MW more of offshore wind capacity, equivalent to a market growth of 71% compared to 2009.

A single European electricity market with large amounts of wind power will bring affordable electricity to consumers, reduce import dependence, cut CO2 emissions and allow Europe to access its largest domestic energy source.

Data sources

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[170] Technology Innovation Needs Assessment (TINA), Offshore Wind Power Summary Report, Innovation Coordination Group, 2012

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Input received from: Vincent de Laleu, Marine & Offshore Wind Energy, EDF Energy

Case 15: Offshore Wind – Optimisation of Turbine Foundation Design

Case presentation: problem definition & opportunities
Overall context
One of the major drawbacks in offshore wind turbine farms to date has been the very high foundation costs. Studies have found that turbine foundation costs (including installation) amount to approximately 20-25% of total capital expenditure costs. Others have claimed that the cost of the support structure for offshore wind installations is close to 40% of the capital expenditure for deeper water sites. Furthermore, as offshore wind turbines increase in size and move further offshore, as the market is currently trending, foundations can be expected to become even costlier. Therefore the development of highly cost effective concepts is required, as the optimisation of the foundation is essential for economic feasibility of offshore wind farms. Deciding on the type of foundation and turbine model for an offshore turbine is a crucial step in constructing an offshore wind farm. These two decisions are inextricably linked as the size, or more precisely, weight of the turbine is a factor in deciding on a foundation type. However, choice of foundation is also determined by water-depth and type of seabed. Furthermore, for environmental and energy gain reasons, wind farms are being located farther from shore in deeper waters. This trend of increasingly large turbines in deeper and rougher waters has seen a proportional increase in the design and construction challenges and complexity. Currently, monopole foundations are used in almost 70% of wind farms, followed by gravity foundations, which represent about 30%. Innovative designs for foundations are constantly being considered and assessed by the industry, and **research is underway to develop new types of jacket foundation**, such as twisted jackets, which are strengthened by specially calculated tensions. Such designs can reduce the use of steel in their manufacture process and thereby reduce costs. Europe leads the way in offshore wind energy. The power generated by offshore wind farms in Europe increased by 51% in 2010, with current installed capacity of 3,295 megawatts (EWEA). Offshore wind energy however is still a fledgling industry in comparison with onshore wind power, The challenges and demands of the installation process are markedly different from onshore installations due to the difficulties of operating at sea. The logistical complexity of these installations and the costs involved in terms of construction place heavy constraints on the industry. The design challenge is to make offshore wind farms an economical and viable source of power.

The need for marine knowledge in Europe
Current knowledge
Sub-structures represent a significant proportion of offshore development costs. It is necessary to extend the lifetime of structures, reduce costs, and develop risk-based life cycle approaches for future designs. New and innovative foundation concepts are constantly being designed and refined by industry and researchers. As the industry matures, more cooperation structures are emerging and existing ones strengthening, as developers cope with the sector's unique set of challenges. However, for the time-being few data are available to the research community from existing experimental offshore test sites, mainly due to the confidentiality of the data, usually property of the manufacturers involved in the projects and because of the highly competitive nature of the market, with many new players having entered over the past few years. There is a need to perform different experiments for the same technologies, and therefore better sharing of knowledge would assist in reducing duplicate research and assist in cost reduction efforts.
Existing initiatives
In Europe, given the potential of the offshore wind sector and to address the prevailing

high costs, there are many initiatives designed to reduce costs and maximise production.

One of these is Offshore Wind Accelerator (OWA), Carbon Trust's flagship collaborative R&D programme. Launched in 2008, the OWA is a joint industry project, involving nine offshore wind developers with 60% (30GW) of the UK's licensed capacity, which aims to reduce the cost of offshore wind by 10% by 2051[171]. As turbines move further offshore, they will be larger and more complicated to install, potentially standing in up to 60m of water, as far as 200km offshore, posing an increasingly complicated set of challenges for an industry in fierce competition with other forms of renewable energies. The OWA works by identifying and prioritising technology challenges on the basis of the likely savings and the potential for the OWA to influence the outcomes. The number one priority identified has been to develop new foundation designs for the 30 – 60 meter water depth that are cheaper and easier to install. In this vein, a global call for tenders was launched in 2000 that

Another project, "OPTI PILE", was financed under the Fifth Framework Programme. This project, looking at the optimisation of monopile foundations for offshore wind turbines in deep water and North Sea conditions, commenced in 2002 and ended in 2004. It was led by E-Connection Project B.V., and also involves Germanischer Lloyd Windenergie GMBH and Vestas Wind Systems A/S. The project funding received amounts to € 1,238,896 out of a total project cost of € 2,753,103.

In addition to data from experimental projects improvements in the provision of other types of marine data would also be useful in the design and development of innovative new foundation designs, particularly detailed seabed data and quality times-series metocean data. In this field as well, a number of initiatives are underway in both the private and public sectors.

INFOMAR (Integrated Mapping For the Sustainable Development of Ireland's Marine Resource) is a joint venture programme between the Geological Survey of Ireland (GSI) and the Marine Institute and is the successor to the Irish National Seabed Survey (INSS). The project intends to cover some 125 000 square kilometers of underwater territory and produce integrated mapping products covering the physical, chemical and biological features of the seabed. Information gathered will include hydrographic maps illustrating everything from sandbars to underwater troughs, seabed classification maps showing the type of sediment on the seabed and habitat maps showing areas which provide homes to a wide range of marine flora and fauna.

In the private sector, vast amounts of detailed data are amassed by companies in the context of normal operation and development of new sites. Most of this valuable data, however, is stored away after use and inaccessible to the research community. A number of industry initiatives exist that are trying to address this issue. For example, in order to stimulate and support a wider application of industry metocean datasets, a System of Industry Metocean data for the Offshore and Research Communities (SIMORC) was established . This service aims at improving awareness of available data sets and has established a systematic indexing and archival of these data sets within the industry.

Type of data needed

At the moment, foundation designs are oversized in order to be conservative; they mainly rely on Oil & Gas standards. There is therefore a need for **available measured data from experimental offshore installations** to validate the existing developed models, supporting research into improved design tools and techniques, and better design standards. Data is needed for different support structures (monopile, jackets, tripods, TLP, etc) and different wind turbine technologies. Better access to the available data of scale models tested could be very useful for ongoing research projects.

To improve and optimise design of the foundation, there is a need for **quality time-series data relating to sea-state parameters**, **currents, sea surface elevation**. As a matter of fact, sea state data (in particular waves and extreme events data) are key for the assessment of loads on substructures. Furthermore, detailed knowledge on soil

[171] http://www.carbontrust.com/our-clients/o/offshore-wind-accelerator

characteristics and scour behaviour is needed before detailed design optimisation can be carried out. It is necessary to have information on the soil conditions to model the dynamic behaviour of the wind turbines. In reference to the procedures for characterization of the soil, it was stated that for deep waters the cost could be very high.

Detailed assessments of the seabed are a vital element of the preparatory work undertaken by or on behalf of developers. **Geophysical surveys** form a part of this. They utilise an advanced, high-tech form of sonar helping operators build up a three-dimensional picture of the seabed, and can tell what materials, such as sand, gravel or chalk, the turbine foundations will be dug into. Geotechnical surveys are carried out to get a better picture of what the seabed is made of up to 80 metres below the bottom of the sea. Such information is crucial when deciding whether an area is suitable for wind turbine construction and how deep the foundations need to be driven.

Marine knowledge 2020

The Green Paper on Marine Knowledge highlights the fast growth of wind energy. Already, 10 % of wind installations are offshore and this proportion is growing, the European Wind Energy Association predicting that by 2020, 30 % of new construction will be offshore and 60 % by 2030. The Paper notes however, that working in this area will inevitably be costlier and riskier than operating on land if all are obliged to carry out separate surveys of the sea bottom, to measure tide and currents, assess marine life that might be disturbed by their activity and monitor risks from tsunamis, storms or unfriendly marine life. Furthermore, it is mentioned that uncertainty is a principal enemy of those responsible for designing offshore structures that can withstand the vagaries of the sea.

While private companies may be hesitant about divulging data from experimental projects, Marine Knowledge has a role to play in ensuring that data generated from publicly financed research is available and easily accessible. All too often, it is the case that the results of these projects are not widely available. Secondly, a number of valuable data are produced or held by public authorities, particularly metocean and seabed data, which would be of use to researchers in this domain. These data are often hard to access and difficult to compile.

Innovative services and benefits

Current/ future services to be developed

The development of new foundational designs is very much in a development stage and no one approach occupies a dominant position in the market. A few examples of the currents innovative kinds of design:

- Twisted jackets : the first design to be installed through the OWA in a demonstration project jointly funded by Mainstream Renewable Power, DONG Energy and the Carbon Trust.
- Tripods: in offshore wind farms the tripod is a new and rarely used structure, though the structure is common in the offshore oil and gas industry. But only the German wind farm Alpha Ventus uses tripods to support six of their wind turbines, the Areva Multibrid 5000.
- Tension Leg platform (TLP): a relatively recent concept for offshore wind turbines (~2005), TLPs float, and researchers estimate they can operate in depths between 100 and 650 feet (200 m) and farther away from land, and they can generate 5.0 megawatts.[172]. TLPs cost less than traditional foundations to make and install because they are assembled onshore, are towed to their destination, and can be moved.

[172] http://www.livescience.com/7183-floating-ocean-windmills-designed-generate-power.html

- Furthermore, with key world markets for expansion characterised by deeper and deeper waters, various types of floating platforms that would all together replace foundations are being experimented with. Floating wind turbines are mounted on a floating structure where bottom-mounted towers are not feasible. The platforms themselves are attached to the sea floor through a number of different mooring systems. While no doubt much different, this research could also benefit from the growing availability of marine data

Economic benefit

The overall economic benefit is a cost effective design optimisation of the turbine foundation. With better knowledge of experimental project results, the seabed as well as sea states, currents and sea surface elevation, foundations can be tailored to the conditions and constructed and installed more economically. Beyond the direct cost savings to wind farm developers, new designs will have a wider beneficial effect across the entire industry, as foundations have been identified as one of the key technical challenges to be overcome as the sector expands.

As an example, the wind farm at Scroby Sands in Norfolk, United Kingdom showed how minor design changes could lead significant savings in construction schedule and costs. The designers decided to make minor modifications to the monopile by welding a flange to which the wind tower could be bolted thereby getting rid of the transition piece and the expensive grouting used to connect it to the monopile altogether.[173]

Furthermore, more comprehensive marine data, especially initiatives such as the INOMAR seabed mapping project, will help better identify advantageous areas for the development of offshore wind farms. In the context of increasingly complicated maritime special planning as offshore users of space proliferate, comprehensive knowledge of the seabed and other relevant data can allow authorities to more effectively allocate space and maximise potential outputs of activity across domains.

Main data sources

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Input received from: Vincent de Laleu, Marine & Offshore Wind Energy, EDF Energy

7 Benefits resulting from a reduction in uncertainty

7.1 Objective

Another objective of the study is to identify how reduced uncertainty due to improved knowledge can have positive economic benefits on marine industries and for the public authorities. It relates to question 16 of the Terms of reference which asks for the contractor to:

> *"provide three more examples of the economic benefits of reduced uncertainty in the behaviour of the sea or the state of the seabed and marine life".*

7.2 Methodology applied

This section presents a number of case studies developed to provide specific examples of economic benefits that could be realised through a reduction in uncertainty regarding the oceans and seas. The methodology applied for developing the case studies is outlined below.

› Initial brainstorming of ideas: based on EC publications, the terms of reference and desktop research, a list of potential examples was developed, for the basis of further in depth research

› In depth desktop research on EC publications, research projects, academic articles regarding past and present initiatives: based on the initial list, potential examples were investigated through a review of academic articles, research projects and other publications. This process also assisted in the identification of potential sector specialists that could be consulted to validate the examples identified.

› Drafting of case study examples: the thorough research was then developed in the form of a case study document, which was organised as follows:

  - Case presentation: problem definition and opportunities, providing an explanation of context and situation in Europe
  - The need for marine knowledge in Europe: explanation of the current state of knowledge in the area, any existing knowledge/research initiatives, the types of data that may be needed to realise the benefits, and the connection to Marine Knowledge 2020
  - Estimations of the economic benefits associated with the reduction in uncertainty
  - Data sources, bibliography, and list of interviews / input received

- Interviews with specialists identified through desktop research: once a draft case study document had been developed, contact was made with identified specialists in order to discuss the content and assumptions in the case study. For each case study example, the contractor has sought to consult at least one sector specialist.

- Incorporation of comments and finalisation: following additional desktop research and specialist interviews, the case studies were finalised.

7.3 Limitations

The quantification of economic benefits resulting from a reduction in uncertainty has required a number of assumptions to be made. The limitations of this part of the study are outlined below.

- Largely based on existing documentation and studies: the identification of examples and their development into case studies is predominantly based on existing documentation and studies publicly available.

- Extrapolations of specific quantitative examples: due to the nature of the case study examples, examples of quantitative benefits have been extrapolated where possible, based on a number of assumptions.

- Specific examples that may not reflect the entire opportunities for sector: due to the fact that three case study examples have been sought for each of key sectors, they do not necessarily reflect all the opportunities and economic benefit for a given sector.

- Specialists do not necessarily represent the views of the entire sector: the specialists have been identified through the desktop research process, and whilst their views provide important input and validation of the case studies presented, their views may not represents the views of the entire sector.

- Challenge in isolating the particular impact of “improved marine knowledge” in generating the economic benefit

› Challenges associated with the quantification of benefits: it is worth reiterating that this exercise has been necessarily quite speculative and hypothetical – the benefits derived from improved marine knowledge may be largely indirect, and therefore difficult to define and quantify. The output for this question is largely qualitative case study examples, with quantitative estimates where possible. Economic modelling was not feasible within the context of this study and its timeframe.

7.4 Summary findings

Detailed case studies for the examples identified are provided in the subsequent section. The table below summarises the findings of these case studies, in terms of the importance of marine knowledge/data and a demonstration or estimation of the economic benefits.

Improved marine knowledge, whether it be through better sharing of datasets on past and present events, improved coordination of research efforts, or other types of specific phenomena, can bring potentially significant economic, social and environmental benefits.

These benefits can be realised through the mitigation of risks and negative impacts, or through a reduction in uncertainty regarding the state of the oceans and seas. The benefits are therefore expressed in a number of different manners, which include:

› Avoidance of lost earnings

› Increase in profitability

› Reduction in costs.

Table 7-1 Case study examples of benefits resulting from a reduction in uncertainty

Title	Hypothesis	Data needs	Economic benefits
Protection of cables for offshore wind	Optimisation of cable protection will reduce risk of damage in long term, reduce costs in installation phase, as well as costs for ongoing maintenance.	Uncertainties would be reduced through better sea-bed data: seabed mapping systems that accurately chart depth, topography, slope angles and seabed type.	Economic damage to cables can potentially be significant as the repair of broken cables is very expensive. Even small areas of mischaracterized seabed can cause significant downtime to repair a damaged cable. The mean time to repair is months for conventional submarine power cables and longer repairs can be expected as cables are laid at deeper and deeper depths. As an illustrative example, in April 2012 the NorNed 700 MW direct-current cable connecting the Netherlands and Norwegian electricity systems failed, **halting production for 10 weeks, and resulting in lost earnings of around € 145 million**. The benefits of protective systems are confirmed through the fact that while cables make up 8% of investment, 80% of insurance enquiries refer to these systems. In an attempt to extrapolate on this example, we need to determine the number of cable failures annually and ideally the average duration of interruption. A study found that there is 1 cable failure per 1,000km of cable per year.[174] To determine the cumulative length of cable for offshore wind structures Europe, we take the total number of turbines (1,662) and multiply this by the average distance to shore of 29km (29km of cable exposed to risk of cable failure), resulting in a total of 48,198km of cable at risk of failure. Taking our previous assumption, if 1 cable failure occurs per 1,000km of cable per annum, there would be **48 failures per year, which would result in lost earnings, based on a 10 week break in production, of € 6.9 billion.**
Site accessibility to optimise operations and maintenance for offshore wind	Better accessibility results in reduced downtime losses, avoidance of energy production losses, and potentially prevention of costly repairs.	Actual weather conditions, forecasts of wind and sea state to optimise O&M. Data on wind turbine failure rate, data from access systems, supply boats, and crane barges, as inputs into models.	**An uplift in the wave height at which maintenance is possible could improve turbine availability from 80% to 90%, translating to a potential saving of £ 245,000 (or € 285,000) per 5MW turbine per year.** If this were applied to 50% of the 1,662 turbines installed and grid connected, totalling 4,995 MW in 55 wind farms in ten European countries at the end of 2012,[175] this would result in **combined savings of € 236.8 million per annum**.

[174] http://ocw.tudelft.nl//fileadmin/ocw/courses/OffshoreWindFarmEnergy/res00047/Module_9_wind_farm_aspects.pdf

[175] EWEA, European Offshore Statistics 2012, http://www.ewea.org/fileadmin/files/library/publications/statistics/European_offshore_statistics_2012.pdf

Hydrographic data to assist optimising ship navigation routes	Improved hydrographic data coverage will positively benefit navigation safety and protection of the marine environment, among many other benefits.	Lack of up-to-date charting and hydrographic survey data. In Europe, the most significant gaps are in the Mediterranean and Black Seas High resolution access to seafloor morphology and texture, covering topography, bathymetry, geology	Improved charts enable **cost reductions through faster transit for ships, more direct routes, reduced insurance costs, and avoidance of maritime accidents**. As an illustration, the National Oceanographic and Atmospheric Administration (NOAA) reported that **one additional foot of draught may account for between $US 36,000 and $US 288,000 (between €28,000 and €225,000) of increased profit per transit** into Tampa, Florida, USA.[176] Furthermore, the **economic benefits and savings associated with preventing marine accidents through more adequate surveys are significant**. For the example of the Sea Diamond, the bill footed by the owner company **cost $US 6 million (€4.7 million)**, while a **floating barrier that has been placed in the area of the wreck is monitored daily by a pollution-control vessel staffed by specialised personnel**, again at the shipowning company's expense.

[176] National Oceanic and Atmospheric Administration (NOAA), (2000), Technical Report NOS COOPS 031, National Physical Oceanographic Real-Time Systems (PORTS) Management Report. Silver Spring, Md.

7.5 Case studies on the benefit of reducing uncertainty

7.5.1 Case 1: Protection of cables for offshore wind

Case presentation: problem definition & opportunities
Overall context
Output from a wind farm is entirely dependent on the integrity of the cables. Offshore wind farms generally use two cable types. The inter-array cable, usually rated from 10 to 32 kilovolts (kV), connects individual turbines to an offshore substation. The export cable, rated at 132kV takes the electricity from the offshore substation to the connection point onshore. However, cables are exposed to a number of different hazards, which have the potential to cut supply, result in long downtime, require expensive repairs and therefore have significant economic consequences. Some of the typical hazards include: › Interaction with recreational vessels, fishing gear, dropped or dragged ship anchors, installation vessels (e.g. jack up for turbine installation) in construction phase › Exposure of the cable due to seabed conditions e.g. sand waves, scour › Exposure of the cable when exposed from unsupported lengths or jagged rocks › Dredging Activities Turbines are links in series to a central power station, from which a much larger export cable sends the farm's total power to land. When a break occurs in a cable within the inter-array on a wind farm, that particular turbine or connected series of turbines trips off. The whole wind farm can therefore be affected as a result of a break in the export cable.[177] Hitting a cable has no severe environmental effects and only a limited safety impact. If a cable is torn, the resulting electrical short may lead to an equipment overload and the shut-down of converter or transformer stations. The offending ship will suffer no electrical shock due to the high electrical conductivity of seawater, resulting in a complete earthing of the damaged cable.[178] The economic damage, however, may be significant as the repair of broken cables is very expensive. The consequential damage to an unprotected export cable can result in many months of downtime. Proper care in laying cables is essential in order to minimise long term repair costs. The Managing Director of Offshore Marine Management in the UK has stated that "the biggest problem for a wind farm once it is operational is the sub-sea cabling. You can have a thousand wind turbines offshore but if you break the export cables no electricity will get into the grid."[179] Fortunately there are measures that can be taken to reduce the likelihood of these negative impacts. Burying the cables is an essential measure to protect cables from immediate damage through getting caught up in fishing gear or anchors. For both export and in-field cabling, the trenches that are created cave in after the machinery has

[177] Phil Walker and Cliff McDougall, Pharos Offshore Group Ltd. "Burial Protection Index for Offshore Wind Farm Power Cable"
[178] http://www.greenpeace.org/international/Global/international/planet-2/report/2006/3/offshore-wind-implementing-a.pdf
[179] Offshore Wind Energy: A UK Success Story - UK Trade & Investment, www.ukti.gov.uk/uktihome/aboutukti/item/310240.html

passed, acting as a self-burying system. There are a number of different techniques of protecting the in-field cables and export cables according to the particularities of a single project.

The optimal protection is to bury the cable just below the depth that the threat can reach. For the most common hazards, only a small depth (often less than 1 metre) is required. However no truly effective measure can be taken against anchors dropped from large ships as, despite the inability to drag a great distance, these modern anchors can dig deep into the seabed. Furthermore, the depth of a trench to completely avoid all potential incidents would be economically unviable.[180]

The need for marine knowledge in Europe

Current knowledge

Studies have found that around 70% of all cable failures associated with external aggression are caused by fishing and shipping activities in water depths shallower than 200 metres.[181] Accordingly, cables are buried for protection, and efforts have been made to increase awareness of cables by other seabed users. These measures have produced a marked fall in the number of faults per 1,000 km of cable.

However further efforts are needed to protect cabling systems in the most economically efficient manner. Existing uncertainties during installation phases mean that solutions are not entirely cost effective. In response to this, a range of cable protection systems have been developed in order to reduce the negative impacts certain phenomena can have on offshore installation cables, a sample of which are outlined below:

- Tekmar Energy Ltd has installed 1,000 protection systems at 18 offshore wind farms. The protection systems basically consist of a casing which is pulled over the cable, preventing damage to the section of cable between the sea floor and the turbine's foundation.[182]
- CPNL Engineering GmbH has supplied a complete cable protection system for the NSO offshore wind project of RWE, a leading utilities company in Germany. The cable protection system of CPNL is the first system that can be adapted to any kind of cable project.[183]
- Circor Energy has developed a cable protection system called PEFLEX, which is used to protect freespan array and export cables on offshore wind farms. Circor is partnering with Dong Energy, E.ON and Masdar to supply Cable Protection Systems for the first phase of the London Array Offshore Wind Farm. The London Array cables require protecting during deployment and during service life from movement due to wave action and other turbulence across the exposed monopile scour zone. The system provides abrasion protection, impact protection, fatigue protection and cable over bending protection, while allowing for quicker deployment and reduced installation costs.[184]
- Blue Ocean Projects (BOP) has also developed a range of Cable Protection Products

180 http://bsee.gov/uploadedFiles/BSEE/Research_and_Training/Technology_Assessment_and_Research/671AA-Final%20Report%20Offshore%20Electrical%20Cable%20Burial%20for%20Wind%20Farms.pdf

181 Kordahi, M.E. and Shapiro, S., 2004. Worldwide trends in submarine cable systems. Proceedings SubOptic 2004, Monaco, Paper We A2.5, 3 pp. Available at Submarine Cable Improvement Group. http://www.scig.net/

182 Windforce 2012 Conference in Bremen, http://www.windforce2012.com/wp-content/uploads/2012/10/Nachbericht_EN_final.pdf

183 http://www.offshorewind.biz/2012/11/14/cpnl-provides-cable-protection-for-german-offshore-wind-farm/

184 http://www.circor.com/solutions/partner-peflex

designed to provide protection for subsea cables at offshore wind or tidal energy foundations, in shallow water and at landfalls, boulder fields or areas of rocky seabed where cable burial is impractical.[185]

In terms of knowledge, geological and geophysical conditions must be known both to the installer and to the cable designer before selection of the installation equipment and for the cable to be designed. Data particularly on soil density and hardness is required in order to improve knowledge regarding options to protect cables. All other factors being equal, "harder" sea floor conditions, measured by geotechnical characteristics, provides buried cable with more protection than "softer" sea floor. This means that cables do not always need to be buried to the deepest possible level to achieve adequate protection.

Furthermore, in terms of recovery and repair, locating cable installed deeper than 1 metre requires a 'tone' listening rather than a 'metal detector' technology. Excessive burial could prevent cable from being located, detrenched or recovered. If an entirely new length of cable needs to be re-installed and buried, this would exponentially add to cost of repairs.

Therefore, whilst the needs for cable burying are well understood, uncertainties regarding sea-bed characteristics mean that the most economically viable or effective solution is not implemented. An overview of the types of data needs to reduce this uncertainty is provided below.

Type of data needed

Uncertainties would be reduced through having better data in a number of areas, including:

Soil resistivity: optimising sea burial requires knowing the soil. Have a clear picture of the seabed soil type will determine the best route and equipment to use for burying cable.[186] For example, generally the deeper you bury a cable, the more expensive it is. However if the soil is particularly hard, it will not have to be buried as deep as if the soil were soft, thus saving on important costs. Deeper burial requires more specialised equipment, more specific operator experience, more time to cover a given distance and larger ships contracted at higher daily rates.[187] It is important to understand the thermal resistivity of the soil and bear in mind that the burying process can change these soil properties.

Sea-bed characteristics: seabed mapping systems that accurately chart depth (the deeper the water the more loads the power cable must absorb during installation), topography, slope angles (exacerbated by severe weather conditions such as a seismic event) and seabed type - as well as on stability, and the location of any rocks or sand waves. The shifting of sand by currents, tides and surf may lead to a cable being exposed, and then itself be exposed to these conditions. An accurate assessment of the potential for scour requires a bathymetric survey to identify sand waves, samples of surface seabed soils, and an assessment of seabed currents.

Regional information: this is needed in order to determine cable life. For example, data is needed on the potential for electrical surges in the cable (e.g. from lightning and other sources) as well as the predicted temperature ranges that the cable will be subjected to at its burial depth and during seasonal fluctuations. Finally, there is also a need for information on historical cable and pipeline installations in the locality; and the location of disused cables, pipelines, munitions, wrecks etc.[188]

Furthermore accurate data on seawater salinity, and any other site-specific factors including meteorological and oceanographic (metocean) data, temperature variations and

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185 http://www.blueoceanprojects.com/cable_protection_products.html
186 Phil Walker and Cliff McDougall, Pharos Offshore Group Ltd. "Burial Protection Index for Offshore Wind Farm Power Cable"
187 Phil Walker and Cliff McDougall, Pharos Offshore Group Ltd. "Burial Protection Index for Offshore Wind Farm Power Cable"
188 Sharples 'Offshore Electrical Cable Burial for Wind Farms: State of the Art, Standards and Guidance & Acceptable Burial Depths, Separation Distances and Sand Wave Effect' 2011

protection requirements, are required in order to have a full picture on the optimal solutions. On the whole, these types of information would improve knowledge regarding options to bury (or not) the cable in order to make decisions regarding how to armour the cable and what armouring is required from risks due to "navigation" e.g. ships and trawlers, rocks, unsupported lengths and from other environmental hazards such as creatures burrowing into the cable. It would also potential reduce the need for repetitive and costly geophysical surveys of the same areas.
Marine knowledge 2020
The Green Paper on Marine Knowledge 2020 mentions industry's need for knowledge particularly in operating offshore. The paper states that offshore will "inevitably be costlier and riskier than operating on land if each offshore facility needs to construct its own ancillary services such as cabling or supply networks", or if all operators are obliged to carry out separate surveys of the sea bottom. Data platforms, such as through EMODnet, would provide one centralised source for these types of data on sea-bed characteristics, which would reduce uncertainty, facilitate the selection of a cabling solutions and potentially reduce future likelihood of costly repairs and periods of downtime.

Benefits
Economic benefit
Economic damage to cables can potentially be significant as the repair of broken cables is very expensive. Even small areas of mischaracterized seabed can cause significant downtime to repair a damaged cable.[189] The mean time to repair is months for conventional submarine power cables and longer repairs can be expected as cables are laid at deeper and deeper depths.[190] Through reducing uncertainty regarding sea-bed characteristics, soil profile, metocean data and other factors such as historical cable and pipeline installations in the locality, companies can optimise the cable protection system employed in order to reduce the risk of damage in the long term, reduce costs during the installation phase through the selection of the most appropriate and cost effective option, as well as reduce costs for ongoing maintenance. An example of the importance of bathymetric survey data was highlighted when a plough was lost due to a sandwave collapse, due to the fact that the slopes had been underestimated. As a result of this incident, the project was delayed and financial implications of this delay were increased by the loss of the plough, and the requirement to source replacement cable.[191] In terms of quantified example of the economic impact that could be avoided through optimisation of cable protection, in 2012 a technical fault with the cabling serving the 300MW Thanet wind farm, off England's south east coast, was reported. The total cost to Vattenfall for the fault was approximately SEK50m (**€ 5.6 million**).[192] The Horns Rev 2

[189] Sharples 'Offshore Electrical Cable Burial for Wind Farms: State of the Art, Standards and Guidance & Acceptable Burial Depths, Separation Distances and Sand Wave Effect' 2011

[190] Johannson 'IceScot Submarine Power Cable from Iceland to Scotland'. 2011.

[191] PG Allan, Hydrographic Information and the Submarine Cable Industry, Hydro 2001, Norwich, March 2001

[192] http://www.windpoweroffshore.com/2012/07/31/thanet_cable_failure_cost_vattenfall_more_than_5m/

installation experienced a failure when an anchor hit the cable which lay unprotected on the seabed. The cost of repairs was € 2 million.[193]

Furthermore, in April 2012 the NorNed 700MW direct-current cable connecting the Netherlands and Norwegian electricity systems failed. NorNed predicted at the time that repairs would take approximately ten weeks. It has been estimated that if Tenne T's 9 offshore wind cable projects connecting 900MW of offshore wind capacity with the mainland **went down for 10 weeks**, whilst operating at 4,400 full load hours per year (as achieved by Germany's first offshore station Alpha Ventus in 2011) **lost earnings could reach around € 145 million**.[194]

In an attempt to extrapolate on this example, we need to determine the number of cable failures annually and ideally the average duration of interruption. A study found that there is 1 cable failure per 1,000km of cable per year.[195] To determine the cumulative length of cable for offshore wind structures Europe, we take the total number of turbines (1,662) and multiply this by the average distance to shore of 29km (29km of cable exposed to risk of cable failure), resulting in a total of 48,198km of cable at risk of failure. Taking our previous assumption, if 1 cable failure occurs per 1,000km of cable per annum, there would be **48 failures per year, which would result in lost earnings, based on a 10 week break in production, of € 6.9 billion.**

Over the last eight years, many **insurance claims** have been needed by offshore developers to cover the costs of damage to cables during the installation and burial processes currently used.[196] James Ritchie from Tekmar Energy has recognized that the benefits of protective systems are obvious, stating that "the cables make up only eight percent of the total investment, but 80 percent of all insurance enquiries refer to these systems".[197]

Main data sources

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Windforce 2012 Conference in Bremen, http://www.windforce2012.com/wp-content/uploads/2012/10/Nachbericht_EN_final.pdf

"CPNL Provides Cable Protection for German Offshore Wind Farm", Nov 2012, http://www.offshorewind.biz/2012/11/14/cpnl-provides-cable-protection-for-german-offshore-wind-farm/

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"Thanet cable failure cost Vattenfall more than €5m", http://www.windpoweroffshore.com/2012/07/31/thanet_cable_failure_cost_vattenfall_more_than_5m/

[193] http://bsee.gov/uploadedFiles/BSEE/Research_and_Training/Technology_Assessment_and_Research/671AA-Final%20Report%20Offshore%20Electrical%20Cable%20Burial%20for%20Wind%20Farms.pdf
[194] http://www.windpowermonthly.com/news/rss/1137126/Germany-proposes-shared-liability-offshore-cable-failures/
[195] http://ocw.tudelft.nl//fileadmin/ocw/courses/OffshoreWindFarmEnergy/res00047/Module_9_wind_farm_aspects.pdf
[196] http://www.pharosoffshoregroup.com/NewsPages/Subsea_cable_burial.htm
[197] Windforce 2012 Conference in Bremen, http://www.windforce2012.com/wp-content/uploads/2012/10/Nachbericht_EN_final.pdf

Germany proposes shared liability for offshore cable failures, http://www.windpowermonthly.com/news/rss/1137126/Germany-proposes-shared-liability-offshore-cable-failures/ Pharos Offshore Group Ltd, http://www.pharosoffshoregroup.com/NewsPages/Subsea_cable_burial.htm Sharples, M, (2011), "Offshore Electrical Cable Burial for Wind Farms: State of the Art, Standards and Guidance & Acceptable Burial Depths, Separation Distances", http://bsee.gov/uploadedFiles/ BSEE/Research_and_Training/Technology_Assessment_and_Research/671AA-Final%20Report%20Offshore%20Electrical%20Cable%20Burial%20for%20Wind %20Farms.pdf Greenpeace International, "Offshore Wind Implementing a New Powerhouse for Europe, Grid Connection, Environmental Impact, Assessment, Political Framework", http://www.greenpeace.org/international/Global/international/planet-2/report/2006/3/offshore-wind-implementing-a.pdf PG Allan, Hydrographic Information and the Submarine Cable Industry, Hydro 2001, Norwich, March 2001 Kordahi, M.E. and Shapiro, S., 2004. Worldwide trends in submarine cable systems. Proceedings SubOptic 2004, Monaco, Paper We A2.5, 3 pp. Available at Submarine Cable Improvement Group. http://www.scig.net/
Input received from: Vincent de Laleu, Marine & Offshore Wind Energy, EDF Energy

7.5.2 Case 2: Optimisation of operations and maintenance for offshore structures

Case presentation: problem definition & opportunities
Overall context
Wind turbines – as for any other type of industrial equipment – require service and maintenance (known as operations and maintenance, (O&M)) along their operational lifetime. O&M constitutes a sizeable share of operational expenditure for an offshore wind farm and, to a certain extent, to the Levelised Cost of Energy (LCOE). It has been estimated that O&M is expected to make up 25% of the costs of a wind farm during its lifetime.[198] For an equivalent onshore project, O&M costs as a percentage cost of the energy is estimated to be between 5-10%.[199] This significant difference can be attributed to the impact of operating a wind turbine in the marine environment where wind turbines have to withstand a harsher maritime environment and where their accessibility for maintenance is restricted by weather and sea-state conditions, as well as distance to shore. Effective access systems to installations for O&M purposes are critical for cost-effective operation of offshore facilities and the safety of personnel involved. Key considerations regarding O&M for offshore structures include the following: **Reliability of the turbines:** turbine manufacturers need to take a different approach in designing offshore turbines so that they are able to withstand typical offshore conditions. The approach taken includes reducing the number of components, choosing better quality components, applying climate control, using automatic lubrication systems for gearboxes and bearings, etc. **Maintainability of the turbines:** if offshore turbines fail, maintenance technicians need to access the turbines and carry out maintenance. Especially in the case of failures of large components, offshore turbines are modified to facilitate these large scale replacements. The maintainability of present day onshore wind turbines is such that similar failures offshore would require more repair time and more expensive repair equipment than onshore structures. **Weather conditions:** offshore weather conditions, especially wind speeds and wave heights, significantly affect O&M procedures for offshore wind farms, with the potential to restrict access to the wind farm by up to 50% in any given year.[200] Maintenance activities and replacement of large components can only be carried out when the wind speed and wave heights are favourable. Preventive maintenance actions therefore tend to be planned in the summer period. During harsh weather conditions turbines cannot be accessed by personnel and crane ships cannot be used for installation and repairs. If failures occur in the winter season, it is possible that turbines cannot be accessed for repairs, and this may result in lengthy downtime and significant revenue losses. **Transportation and access vessels:** for current day offshore wind farms, small boats are used to transfer personnel from the harbour to the turbines. If the weather is not favourable, helicopters can be used. For medium-sized components, such as a yaw drive, main bearing, or pitch motor, it is often necessary to use a larger vessel for transportation. However some boats may not be able to access during periods of high waves and tidal constraints. Therefore, the right balance must be found between maximising energy production while minimising O&M costs for offshore structures. Uncertainty regarding weather conditions –

[198] Highlights and Islands Enterprise, Offshore Wind: Operations and Maintenance, A National Renewables Infrastructure Plan Stage 2 Information Paper.
[199] Garrad Hassan company 2006, “Operation and Maintenance of wind farms stream”, European Wind Energy Conferencen 2006.
[200] Highlights and Islands Enterprise, Offshore Wind: Operations and Maintenance, A National Renewables Infrastructure Plan Stage 2 Information Paper.

wind speed and wave high – can result in higher O&M costs. The economic viability of offshore wind farms is affected by the reliability and downtime of offshore wind turbines, accessibility of offshore wind farms, the transportation means, the distance to shore and the wind turbine system configuration.

The need for marine knowledge in Europe

Current knowledge

To maximise energy production it is essential that wind turbine failures be addressed quickly. The current O&M practice for existing offshore wind farms can be described as a generally reactive response. Essentially, when an item fails and the wind turbine becomes non-operational, a maintenance expedition is launched at the first opportunity to carry out the repair. This visit is additional to planned routine preventative maintenance visits.[201]

The corrective maintenance strategy has been applied to the offshore wind farms since early development. The main reason for this is the first offshore wind farms were prototype projects and consisted of a small number of wind turbines, located very close to shore. Given there was a need to demonstrate high energy harness in order to attract funding, this resulted in high numbers of maintenance expeditions, a practice that has been adopted for existing offshore wind farms. [202] Whilst this approach to maintenance for offshore wind farms has been effective in maintaining high levels of availability, it has been found to be expensive due to the majority of offshore wind turbine failures and weather dependant accessibility being unpredictable. [203]

In order to minimise the number of expensive offshore repair operations, it is necessary to carry out preventive maintenance based on accurate and efficient condition monitoring systems. However regular preventative maintenance requires regular and easy access to installations. The impact of uncertainty in weather conditions is that it is difficult to be sure whether/when site can be accessed by boat for O&M or even during construction.

Some maintenance strategies remain very similar to the strategy for land. Two times a year a service and preventive maintenance visit is made to each wind turbine, preferably when the wind and sea conditions are favourable. Repair actions are carried out when maintenance crew and equipment are available and weather permits.[204] With better data on wind and sea state forecasts, this process could be improved.

A study has found that wind turbines at the North Sea can be accessed between only 60 to 70% of the time.[205] Therefore improved access systems are required for large scale offshore wind. The diagram below represents availability as a function of vessel accessibility of a 100 unit offshore windfarm, undertaken as part of a research project into the "Development of an Expert System for the determination of Availability and O&M Costs for Offshore Wind Farms".[206]

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201 Karyotakis, A. (2011), "On the Optimisation of Operation and Maintenance Strategies for Offshore Wind Farms", University College London

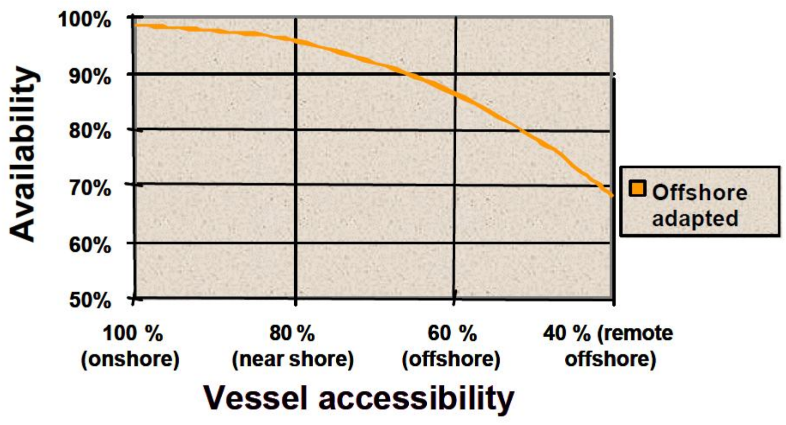
202 Karyotakis, A. (2011), "On the Optimisation of Operation and Maintenance Strategies for Offshore Wind Farms", University College London

203 Karyotakis, A. (2011), "On the Optimisation of Operation and Maintenance Strategies for Offshore Wind Farms", University College London

204 http://www.offshorewindenergy.org/ca-owee/indexpages/downloads/Brussels01_O&M.pdf

205 Energy research Centre of the Netherlands, (2010), "Installation, operations and maintenance", WE@Sea programme – Large-scale wind power generation offshore

206 van Bussel, G.J.W, "The Development of an Expert System for the determination of Availability and O&M costs for Offshore Wind Farms"



Danish offshore sites, such as Vindeby and Tuno, have an average accessibility by vessel of approximately 85%. In harsher conditions, such as in the North Sea, the accessibility with a standard vessel can drop as low as 60%.[207] Thus there is a strong call for improved access methods in order to improve the availability of a wind farm and hence its economic viability.

However, data to assist in optimising O&M can be difficult to obtain. As an example, the We@Sea initiative noted this difficultly, and therefore developed its own databases with reliability figures, access systems, and weather conditions to form the starting point for scenario studies. To optimise O&M scenarios data is needed from measurement programs, SCADA (Supervisory Control And Data Acquisition) systems and condition monitoring systems, and failure and repair data is needed to enable condition based maintenance.

New expert systems and planning models are being developed to take into account weather conditions, failure characteristics of wind turbine components, and the access and docking characteristics of maintenance vessels. Various systems have been developed to transfer personnel, tools and spare parts from a moving ship to a wind turbine safely.[208]

A number of access systems have been developed and applied successfully, including:[209]

- Offshore Access System OAS developed by Fabricom Oil & Gas BV
- The Ampelmann: stabilises an access platform in waves of up to 2.5 m wave height. This means an increase up to 93% in accessing time of a wind turbine in the North Sea.
- WindCat, a catamaran vessel designed and exploited made by Windcat Workboats.
- The Carbon Trust through the Offshore Wind Accelerator programme is investing in 5 key areas, one of which is "Access systems" to transfer technicians and equipment onto turbines for operations and maintenance in heavier seas. MOTS is one of these turbine access systems awarded funding by the programme in 2011. MOTS is a heave motion-compensated robotic arm designed for offshore turbine access.

However these systems and models rely on accurate data in order to maximise O&M accessibility at the lowest cost.

Type of data needed

The ability to maintain offshore wind turbines is very much dependent upon the access

[207] http://www.offshorewindenergy.org/ca-owee/indexpages/downloads/Brussels01_O&M.pdf
[208] Energy research Centre of the Netherlands, (2010), "Installation, operations and maintenance", WE@Sea programme – Large-scale wind power generation offshore
[209] Energy research Centre of the Netherlands, (2010), "Installation, operations and maintenance", WE@Sea programme – Large-scale wind power generation offshore

system used. The actual weather conditions at the site, and its forecast are important for planning transport of maintenance crews and landing using vessels.[210] Therefore better **wind and sea state forecasts** are essential in optimising operations and maintenance and setting the O&M strategy. There is also a need for data on the **wind turbine failure rate**, data from access systems, supply boats, and crane barges, in order to input into models to optimize O&M strategies.

As a basic illustrative example, looking at the average weather and sea state conditions for different months throughout the year for the UK and the North Sea such as through the Met Office's Marine Automatic Weather Station, it is possible to identify the best time of the year to undertake maintenance. Considering the fact that the offshore wind farms are reported to be accessible only when wave height is lower than 2 metres, it can be concluded that the period between May and October is appropriate, and that between November and April, where average wave heights exceed 2 metres accessibility to offshore wind turbines becomes very difficult or even impossible.

Other studies have developed detailed models and software programmes in order to calculate when weather permits O&M to be scheduled. The examples below provide information on the types of data that are required to have a reliable model to optimise O&M.

- Within the scope of the DOWEC (Dutch Offshore Wind Energy Converter) project, the required weather windows are determined on basis of the NEXT/NESS (North European Storm Study) database. An estimate of the availability of an offshore wind farm can be realised in an advanced way using a Monte Carlo simulation model of the O&M operations within the wind farm.[211]
- The We@Sea programme produced a Waiting Time analysis, which uses data on wind and waves. Based on wind and wave data for a selected location, the program determines when the weather conditions are suitable for carrying out certain repair actions and calculates the average time one has to wait before a suitable weather window will occur after a failure. The program uses time series with three hourly wind and wave data as input, and is based on 11 years of measured data.
- Another software program that resulted from the We@Sea programme was the ECN O&M Tool for determining the O&M costs and downtime of an offshore wind farm. The program uses among others inputs such as weather windows and waiting time polynomials (from Waiting Time); wind turbine and wind farm information such as number of wind turbines, capacity factor of the wind farm, investment costs of turbines, costs of technicians, length of working day; failure behaviour of the turbines and the repair actions which are foreseen; characteristic values of access systems (weather limits, costs, mobilisation time, etc.); and preventive maintenance actions with costs and long term fixed costs like annual contracts.

Marine knowledge 2020

Whilst there is no specific reference to O&M of offshore structures in the Green Paper on Marine Knowledge 2020, there is a reference to the "potential benefit to the whole offshore industry of obtaining better knowledge of potential threats such as rogue waves". Furthermore, the paper mentions the high costs that would result from all offshore operators having to measure tide and currents and monitor risks from tsunamis, storms, etc. The European Earth monitoring programme (GMES) offers a unique sea-basin level source of information for past, present and future ocean observations relating to different parameters such as sea temperature, currents, salinity, sea ice, sea level, wind and biogeochemistry. This type of data platform would minimise the effort and cost required in future data collection, and reduce the uncertainty regarding the ocean state, by providing accurate past, present and forecast data.

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[210] http://www.ecn.nl/fileadmin/ecn/units/wind/docs/dowec/2003-OWEMES-Accessibility.pdf
[211] http://www.ecn.nl/fileadmin/ecn/units/wind/docs/dowec/2003-OWEMES-Accessibility.pdf

Benefits
Economic benefit
The benefit to be gained from reduced uncertainty regarding wind and sea state forecasts is cost savings through the optimization of O&M made possible through better accessibility to sites. This will result in reduced downtime losses, avoidance of energy production losses and thus revenue losses, and potentially prevention of costly reactive repairs in the future. In time of harsh weather conditions (wind, waves and visibility), a wind farm may be inaccessible by boat or helicopter for a period of one or two months.[212] Constrained access can render even seemingly simple things, such an anti-corrosive paint touch-up on the towers, a crippling cost variable. A report on "Offshore Operations and Maintenance"[213] notes that where the protective coating on the tower has been inadequate, the cost of a paint job can be as high as one hundred times the cost of the job in the paint shop due to logistic complexities in getting personnel and materials to the site. Furthermore, where sea access is the only possible option, far offshore sites can face up to 50% weather-related down time. An increase in heave could result in as many as 120 days of down time.[214] Houlder Ltd, an engineering company specialising in the marine environment, has calculated that an uplift in the significant wave height at which maintenance is possible could improve turbine availability from 80% to 90%. This would translate to a **potential saving of £ 245,000 per 5MW turbine per year**.[215] If this were applied to only half of the 1,662 turbines installed and grid connected, totalling 4,995 MW in 55 wind farms in ten European countries at the end of 2012,[216] this would result in combined savings of € 236.8 million per annum. Another illustration of the economic benefits of optimised O&M resulting from reduced uncertainty relates to condition-based monitoring (CBM). CBM refers to a system of sensors installed inside the turbines, which has the potential to significantly reduce costs. CBM provides diagnostic information about the health of components of an operating wind turbine. Using such data helps wind farm operators estimate the deterioration that may lead to major failures or consequential damages, and accordingly, establish appropriate maintenance policies in advance. A few studies have attempted to quantify the benefits of CBM in the wind power industry. McMillan and Ault have evaluated the cost-effectiveness of CBM via Monte Carlo simulations. Through simulating various scenarios with different weather patterns, down-time durations, and repair costs, they show for land-based turbines that a CBM strategy could provide the operators economic benefits of **£ 225,000 per turbine**, when considering fifteen years as a turbine life.[217]

Main data sources

[212] http://www.ecn.nl/fileadmin/ecn/units/wind/docs/dowec/2003-OWEMES-Accessibility.pdf
[213] Wind Energy Update, "Offshore Wind Energy Operations and Maintenance : Optimise your operations and maintenance strategy by identifying the true costs, downtimes and failure rates of modern and future wind farms"
[214] Wind Energy Update, "Offshore Wind Energy Operations and Maintenance : Optimise your operations and maintenance strategy by identifying the true costs, downtimes and failure rates of modern and future wind farms"
[215] http://social.windenergyupdate.com/offshore/turbine-access-innovation-makes-farshore-wind-viable
[216] EWEA, European Offshore Statistics 2012 ,http://www.ewea.org/fileadmin/files/library/publications/statistics/European_offshore_statistics_2012.pdf
[217] D. McMillan and G.W. Ault, "Condition monitoring benefit for onshore wind turbines: sensitivity to operational parameters," IET Renewable Power Generation, vol. 2, pp. 60–72, 2008.

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Input received from: Vincent de Laleu, Marine & Offshore Wind Energy, EDF Energy

7.5.3 Case 3: Hydrographic data to assist in optimising navigation routes of ships

Case presentation: problem definition & opportunities
Overall context
Hydrography deals with the measurement and description of the physical features of oceans, seas, coastal areas, lakes and rivers, as well as with the prediction of their change over time, for the primary purpose of safety of navigation and in support of all other marine activities, including economic development, security and defence, scientific research, and environmental protection. A mariner obtains navigation information from several sources, including nautical charts (paper or electronic) and text publications such as sailing directions and port guides. Charts provide depictions of geographic data, whilst nautical publications provide general guidance and non-geographic information, such as extracts from navigation and other regulations, information about vessel traffic services, radio services, natural conditions, hazards and obstructions, and overviews of coastal areas and routes. In addition to charts and nautical publications, mariners use recent or real-time information including weather, navigational warnings, etc. Over 90% of international trade is transported by sea. A fundamental requirement for the safe transportation of goods is adequate nautical charting. Yet despite this massive reliance upon sea transportation many areas and regions do not have adequate cartographic coverage. Furthermore, both in European waters and in other areas of interest for European shipping, the quality of survey data is not yet sufficient to ensure the safety of navigation, particularly outside the main shipping lanes or for extremely large vessels.[218] The International Hydrographic Organization (IHO) is an inter-governmental consultative and technical organization, governed by an international Convention. Established in 1921, the IHO is a competent international organization, as referred to in the United Nations Convention on the Law of the Sea. The IHO's mission is to facilitate the provision of adequate and timely hydrographic information for world-wide marine navigation and other purposes through the co-ordination of the work of national hydrographic offices. It also coordinates on a worldwide basis the setting of standards for the production of hydrographic data and the provision of hydrographic services in accordance with the SOLAS Convention. Through Regional Hydrographic Commissions, there is regional coordination of nautical information, hydrographic surveys, production of nautical charts and publications, training, technical cooperation, and hydrographic capacity building projects. The IHO maintains a publication, C-55, on the IHO website that aims to detail and describe the current status of Hydrographic surveys for each maritime state. Many IHO member states are tasked with collecting nautical information and surveying international waters that would otherwise remain uncharted. However, it is often the case that hydrographic officers only learn by accident of surveys that have been performed by private companies.[219] According to IHO's latest version of the C-55, there are still large gaps in major international shipping routes in the Indian Ocean, South China Sea, Western Pacific and adjacent waters. In the Caribbean, some coastal waters of Africa, Australasia, Oceania and the Antarctic, modern surveys, metrication and datum shift to WGS 84 are all urgent requirements in locations which are now frequented by cruise liners. In the last 50 years, there have been significant oil tankers accidents in Europe and around the world (1979, Atlantic Empress, Tobago; 1989 Exxon Valdez, Alaska)

[218] Response to Green Paper prepared by SHOM, 2012
[219] Minutes of the 9th Southern African and Island Hydrographic Commission (SAIHC) Conference, 18-19 September 2012

which argue the need for a better cartography of the seabed for a safer navigation.

Where charting is inadequate, shipping companies will deploy a fleet that is older, less efficient and capable, and more likely to be involved in a maritime accident due to the age of the equipment and competence of the crew.[220] Improved knowledge of hydrography through, for example, open access to data from private operators, will positively benefit safety of navigation and protection of the marine environment, among many other benefits, such as national infrastructure development, coastal zone management, marine exploration, resource exploitation and disaster prevention and response.

Most marine accidents, (groundings in particular) are the result of operator error. Approximately 25% of all serious ship accidents occur in coastal waters or during harbour approach. Of these, greater than 75% result from insufficient information, mistaken interpretation or assessment, and lack of timely preventative action.[221] In addition, 70% of all marine insurance claims are related to navigational incidents, which again add to indirect costs in the form of additional premiums, call money etc. Enhanced safety thus also means lower costs.[222]

The introduction and implementation of Electronic Chart Display and Information Systems (ECDIS) and Electronic Navigation Charts (ENC) into the maritime industry has the potential to significantly reduce the margin for human error during navigation scenarios.

The need for marine knowledge in Europe

Current knowledge

The EMODnet Hydrography portal provides hydrographic data collated for a number of sea regions in Europe:

- the Greater North Sea, including the Kattegat and stretches of water such as Fair Isle, Cromarty, Forth, Forties,Dover, Wight, and Portland
- the English Channel and Celtic Seas
- Western Mediterranean, the Ionian Sea and the Central Mediterranean Sea
- Iberian Coast and Bay of Biscay (Atlantic Ocean)
- Adriatic Sea (Mediterranean)
- Aegean - Levantine Sea (Mediterranean).

The portal development was initiated in June 2009 and the provision of bathymetric data products has been available to users since June 2010. Construction of a (1/8’) gridded digital terrain model covering all European waters has started and will be available in 2014. Lower resolution data from sources such as GEBCO will fill in the areas where higher resolution survey data are not available.

The key work objective is to achieve global coverage and availability of high quality official hydrographic data, information, products and services necessary for safety of navigation at sea and for non-navigational uses, e.g. by means of the developing spatial

[220] Brinkman, G. L., and S. L. Caverley. (1992) “Benefit-Cost Assessment of the Canadian Hydrographic
Service”; Report prepared by Intercambio Limited for Canadian Hydrographic Survey, Ottawa

[221] Hecht, H., Berking, B., Buttgenbacj, G.,Jonas, M., Alexander, L (2002), The Electronic Chart, Functions, Potential and Limitations of a New Marine Navigation System, GITC

[222] Hydro International, (2011), “Paperless Navigation – Better Now Than Later”, January-February 2011, Volume 15, Number 1, http://www.hydro-international.com/issues/articles/id1237-Paperless_Navigation__Better_Now_Than_Later.html

data infrastructure.

In addition, the IHO undertakes ongoing work to improve the state of Hydrographic data available worldwide. The third edition of IHO Publication No. 55 (C-55), last updated in September 2011 presents a clear picture of the worldwide coverage of surveys and nautical charts and of the extent of effective organisations for the timely promulgation of navigational safety information. The database covers the waters of 90% of the coastal states of the world.

Significant progress has been made in some areas of great importance to international shipping and to the protection of coastal environments. This has mainly resulted from the firm requirements laid down by the IMO before ship routing systems can be approved. There is also encouraging evidence of regional co-operation to provide modern coverage of maritime shipping routes.

However regional studies indicate that there is a lack of up-to-date charting and hydrographic survey data in many developing maritime areas. It is most likely that some hydrographic surveys undertaken do not meet the required international specifications, or the data is restricted or lost.

The UK Hydrographic Office's mariner's handbook suggests that "before using a chart to plan or navigate a passage, mariners should make themselves aware of the quality of the survey data that has been used to place the soundings and contours on the chart, since not all sea areas have been surveyed to modern standards or even systematically surveyed at all. Indeed large areas of sea, especially in offshore areas, have never been systematically surveyed to any standard".[223]

Existing initiatives

Beyond EMODnet, there are a number of important existing regional and national projects of mutual interest.

- MONALISA is a Motorways of the Sea project for the development, demonstration and dissemination of innovative e-navigational services to the shipping industry. Quality assurance of hydrographic data for the major navigational areas in Swedish and Finnish waters in the Baltic Sea contributes to improving safety and optimization of ship routes.
- BLAST - Bringing Land and Sea Together - was a regional project completed in 2012 for better integration of information across the coastal North Sea region. Over three years, 17 partners from 7 countries, including governmental organisations, universities and private companies, collaborated on the harmonisation and integration of land and sea data. As part of this programme, the Digital Mariners Routeing Guide project providing nautical chart data and publications contents for three countries in the North Sea region aimed to demonstrate the potential benefits of using trans-nationally harmonised data in products that can improve maritime efficiency and safety.
- Litto3D is a joint project of SHOM and IGN to produce a seamless geographic reference for coastal zones. Litto3D's two main goals are to merge topographic and bathymetric data into a single database to be released to the public, and to produce a modern, dense, seamless, integrated digital terrain model.
- The IdealShip project is investigating the key design and operating factors affecting the safety of ship operations in order to develop methodologies that optimise navigation and engine control systems for safe operations and efficient performance. Ultimately, these methodologies will be translated into new International Maritime Organisation (IMO) standards related to energy efficiency. The project is lead by Marifuture, the European Platform for Maritime Education, Research, and Innovation.

Type of data needed

[223] UK Hydrographic Office, Mariner's Handbook, 9th Edition, December 2009

Navigational routes are determined based mainly on the bathymetric characteristics of the area. Routes must provide ships a safe clearance and sufficient manoeuvring area for the operations, especially in restricted waters, due to the narrow of the passages, the existing depths and currents. Poorly charted areas and a lack of relevant information will cause voyages to be longer than necessary, and may prevent the optimum loading of ships, thus increasing overall costs. Nautical charts, representing all the required hydrographic information for this purpose, is considered to be main aid to navigation.

As introduced above regional hydrographic studies have revealed that there is a lack of up-to-date charting and hydrographic survey data in many developing maritime areas. It is most likely that some hydrographic surveys undertaken do not meet the required international specifications, or the data is restricted or lost. In Europe, the most significant gaps are in the Mediterranean and Black Seas.[224] A few examples include:

- Hydrographical surveying
    - Malta's coastal areas and the Hurd Bank require a resurvey, as they are currently covered only by 1950s surveys.
    - Adriatic Sea requires a survey of portions of the proposed mid-Adriatic TSS for international routes, a survey of outer approaches to principal ports for regional routes, as well as surveys of routes between principal ports.
    - Off Cyprus, areas of port developments are the priority for re-survey effort
    - For Slovenia, top priorities include surveying of the area of intended TSS near boundary with Italy, especially to survey PA wrecks, as well as around Koper, after completion of dredging and pier construction.
- Nautical charts
    - In Greece, a number of large scale charts need updating

In addition, there needs to be a better exchange of information concerning surveys, research and scientific and technical developments, between the public and private sectors, in order to bridge knowledge and uncertainty gaps. The IHO encourages the sharing of data from research projects as it relates to charting purposes, and SHOM has argued that for all survey contracts awarded to private survey companies, hydrographic data pertinent to the safety of navigation should be made available to the IHO recognized charting authority.[225] Most Hydrographic Offices are more or less requested by their governments to generate some revenues as part of their economic model. DG MARE has noted however that few organisations generate significant revenue from raw data and that by opening the market they would allow other operators to generate new products.

Marine Knowledge 2020

The Green Paper on Marine Knowledge notes the vision for a seamless multi-resolution digital seabed map of European waters by 2020. Hydrography is one of the six thematic assembly groups that bring together a network of 53 organisations. The group includes hydrographic offices, and oceanographic institutes that already manage marine data themselves, as well as private companies with expertise in data processing and dissemination. The vision for EMODnet with respect to hydrographic data covers:

- highest resolution possible in areas that have been surveyed;
- free of restrictions on use;
- topography, geology, habitats and ecosystems;
- accompanied by timely information on

[224] IHO Publication C-55, http://www.iho.int/iho_pubs/CB/C-55/C-55_Eng.htm.
[225] Minutes of the 9th Southern African and Island Hydrographic Commission (SAIHC) Conference, 18-19 September 2012

- physical, chemical and biological state of the overlying water column
- oceanographic forecasts;

- together with a process that helps Member States maximise the potential of their marine observation programmes

The overall objective of EMODnet is to create pilots to migrate fragmented and inaccessible marine data into interoperable, continuous and publicly available data streams for complete maritime basins.

Benefits

Economic benefit

The economic impacts of hydrography and bathymetry on safety of navigation have been studied for a number of years. A Canadian Study in 1992 has estimated the return on investment from having a national hydrographic program in the order of 1:10.[226] Given this cost/benefit ratio, countries should have an incentive to properly chart their waters.

Improved charts may allow for faster transits of ships with deeper draughts, resulting in a greater amount of goods moving through navigational choke points and ports. Hydrography and bathymetry are equally needed to support the development of strategies to sustain and protect ocean resources.

The economic profitability of commercial shipping relies particularly on current nautical charts. Reliable charts provide the most direct routes between ports, reduce the number of pilots required, decrease the number of groundings (and reduce insurance rates), and allow deeper draft vessels (i.e. more cargo) to be used. The National Oceanographic and Atmospheric Administration (NOAA) reported that one additional foot of draught may account for between **$US 36,000 and $US 288,000** of increased profit per transit into Tampa, Florida, USA.[227]

The economic benefits and savings associated with preventing marine accidents through more adequate surveys are significant. The cost of an oil spill can be measured by the revenue lost through the loss of cargo, the vessel and days at sail, as well as the cost of cleanup. For the example of the Sea Diamond, whilst a report released by the Hellenic Centre for Marine Research argued that the impact of the wreck on the marine ecosystem in Santorini was negligible, the approximately 450 tons of fuel that leaked into the sea after the Sea Diamond sank was cleaned up by a private company, with the bill footed by the owner company at a cost of 6 million dollars, while a floating barrier that has been placed in the area of the wreck is monitored daily by a pollution-control vessel staffed by specialised personnel, again at the shipowning company's expense.

The impact of oil spills can be even greater than this in economic and environmental terms. For instance, the sinking of the Erika cost a total of **€ 350 million** : € 180 million spent by central government, € 140 million spent by Total to clean up difficult access sites, etc. and € 30 million spent by local government in cleaning and repairing the coast.[228]

In addition to navigational benefits and maritime safety, improved hydrographic data provides the following complementary benefits:

- Coastal zone management: disaster modeling is made possible by high resolution

[226] Johnston, G., (2011), "The Economic Benefits of Hydrography and Ocean Mapping", featured in International Federation of Surveyors, (2011), "Report on the Economic Benefits of Hydrography", FIG Publication no. 57
[227] National Oceanic and Atmospheric Administration (NOAA), (2000), Technical Report NOS COOPS 031, National Physical Oceanographic Real-Time Systems (PORTS) Management Report. Silver Spring, Md.
[228] Cedre, (2011), "Impact de la pollution",http://www.cedre.fr/fr/accident/erika/impact.php

bathymetry data, and with high resolution coastal data, an accurate set-back zone can be determined

- Offshore aquaculture production and fisheries: as fish tend to congregate in shallow waters, with precise bathymetry information, it is easier to determine where the fish are.
- Climate Change, natural disasters, pollution, and hazard mitigation: bathymetry is a baseline element in terms of storm surge modelling, and wave hind casting.
- Tourism: data can offer new and unspoilt locations, and assist in maintaining coastal waters, bays, beaches and islands.
- Ports and harbours: investment decisions for port expansion need up to date data, in particular to provide safe berthing and passage for an increasing number and size of vessels.

Main data sources

Cedre, (2011), "Impact de la pollution", http://www.cedre.fr/fr/accident/erika/impact.php

Douglas Connon, B., Nairn, R. (2011), "Economic Impact of Hydrographic Surveys", featured in International Federation of Surveyors, (2011), "Report on the Economic Benefits of Hydrography", FIG Publication no. 57

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Interviews :

Yves GUILLAM and Yves-Henri RENHAS, Service Hydrographique et océanographique de la marine (SHOM)

8 Options for governance of European marine observation and data networks

This section on the governance of European marine observation and data networks aims to answer the evaluation questions in ToR, namely:

› (17) How would such an arrangement work? Are there any examples (other than EU Agencies)?

› (18) Could it be done through the Joint Programming Initiative on Healthy Seas and Oceans? Or through the Joint Research Centre? Or through an executive agency? Or through a public-private partnership? What would be the costs and benefits in each case?

It is further mentioned in ToR that "An ideal secretariat would (1) deliver an annual work programme to achieve a set of objectives.(2) negotiate approval of the work programme with a "governing board" (3) implement the work programme in a way that is compatible with the EU's Financial Regulation."

8.1 Marine Knowledge – the governance context

The Integrated Maritime Policy (2007) seeks to provide a more coherent approach to maritime issues, with increased coordination between different policy areas. Specifically it covers these cross-cutting policies:

e) Blue growth
f) Marine data and knowledge
g) Maritime spatial planning
h) Integrated maritime surveillance
i) Sea basin strategies

In September 2010, the EC adopted an agenda "Marine Knowledge 2020" that provides common objectives for all EU marine data initiatives and identifies a number of actions that would achieve these objectives.

The creation of marine knowledge begins with →observation of the sea and oceans. → Data from this observation are assembled, → then analysed to → create information and knowledge. →Subsequently the knowledge can be applied to deliver smart sustainable growth, to assess the health of the marine ecosystem or to protect coastal communities.

EMODNet

The European Marine Observation and Data Network (EMODNet) is concerned by the first two stages of the process chain – i.e. data collection and assembly. Data collection is mostly the responsibility of Member States. The EU has the potential to add value in the assembly phase by ensuring coherence across borders and between different user communities. It is not the first or only initiative that aims to provide better dissemination of marine data. Indeed "Marine Knowledge 2020" emphasises that it is only one of a number of complementary EU efforts.

Preparatory actions

To test how this could be achieved, a number of preparatory actions were started in the period 2008-2010. Several consortia comprising marine data organisations were selected through calls for tender. Prototype websites (portals) were established through procurement contracts providing access to marine data, metadata and data products for six themes[229] and for whole sea-basins.

Text box 8-1 Aim of portal websites

The portals facilitate overview and access to the available data for a given sea basin. Engineers and scientists can see and download both original observations and derived data products such as digital terrain models, sediment distributions and marine habitats.

The portals should provide access to:
(1**) Data** – raw observations or measurements.
(2) **Metadata** – information about the data such as location and time of measurement, units, precision.
(3) **Data products** – products derived from the data; normally by interpolation in space and time. Data products include digital terrain models on regular grids or geological maps. The predicted habitat maps are also a product, developed through integration of other data sets. Thus users can obtain estimates of parameter values between measurement points.

The aim of EMODNet is not to construct a database. The data may remain in separate archives but they should be accessible through a single entry point or so-called "portal". Six different portals were initially set up to facilitate the different types of data requirement and approaches.

The funded preparatory action was not sufficient to cover data from all European seas so each one covers a subset of the sea-basins. Each portal includes the North Sea and at least two other sea basins. All European seas subject to the Marine Strategy Framework Directive, except Macaronesia, are included in at least one portal.

Consortia

[229] Hydrography, geology, physics, chemistry, biology and physical habitats

The consortia are the principal nodes of EMODNET. Each consortium is a group of experts in particular field. Their tasks are the following:

› Ensure that participating institutions and national data centres use the same standards and metadata.

› Facilitate access to all data and metadata through a single common web page or "portal"

› Develop data products for whole sea-basins and provide access to them through the same portal.

The Table below provides an overview of the current 7 consortia comprising 53 different organisations. The participating organisations are largely public bodies responsible for managing marine data at the national level, as well as some smaller private companies with specific data management expertise.

Table 8-1 Overview of the prototype websites

Thematic group	Type of data	Main contractor	Start	Coverage
Hydrograph	water depth, coastlines, underwater features	MARIS b.v, Netherlands	29/05/2009	North Sea, Celtic Seas, the Western Mediterranean, the Ionian Sea and the Central Mediterranean;
Hydrography	water depth, coastlines, underwater features	MARIS bv, Netherlands	08/06/2010	Eastern Mediterranean, Black Sea, Iberian Atlantic and Biscay
Geology	sediments, strata, coastal erosion, geological hazards	NERC BGS, UK	16/07/2009	North Sea, Baltic and Celtic Seas
Physics	temperature, waves, currents, sea-level, light penetration	ETT, Italy	17/12/2010	All European seas
Chemistry	concentration of chemicals in water, sediments and biota	OGS, Italy	04/06/2009	North Sea, Black Sea and selected parts of Mediterranean
Biology	abundance of living species	VLIZ, Belgium	15/05/2009	North Sea, Bay of Biscay and the Iberian Coast
Physical habitats	habitat classification based on physical parameters: water depth, light penetration, sediments	JNCC, UK	18/02/2009	North Sea, Celtic Seas, Baltic and Western Mediterranean
Human activity	Gravel extraction, aquaculture, shipping	-	To be created	

EMODNet – next phase

The next phase of EMODNet is being funded through Regulation 1255/2011, which is intended to support the maritime policy until the proposed European Maritime and Fisheries Fund is in place for the period 2014-2020[230].

The next phase will focus on:

- Providing access to *more* data, metadata and data products by completing the work started in the first phase in order to deliver complete coverage of European waters by the end of 2014.
- Creating an extra thematic group to assemble data on human activity (gravel extraction, aquaculture, and shipping). This is of particular interest for marine spatial planning.
- Starting a process to identify the fitness for purpose of the present EMODNet and develop evidence based priorities for further work in collecting, assembling and processing marine data.
- Evaluating sustainable and cost-effective mechanisms for the EMODNet infrastructure.

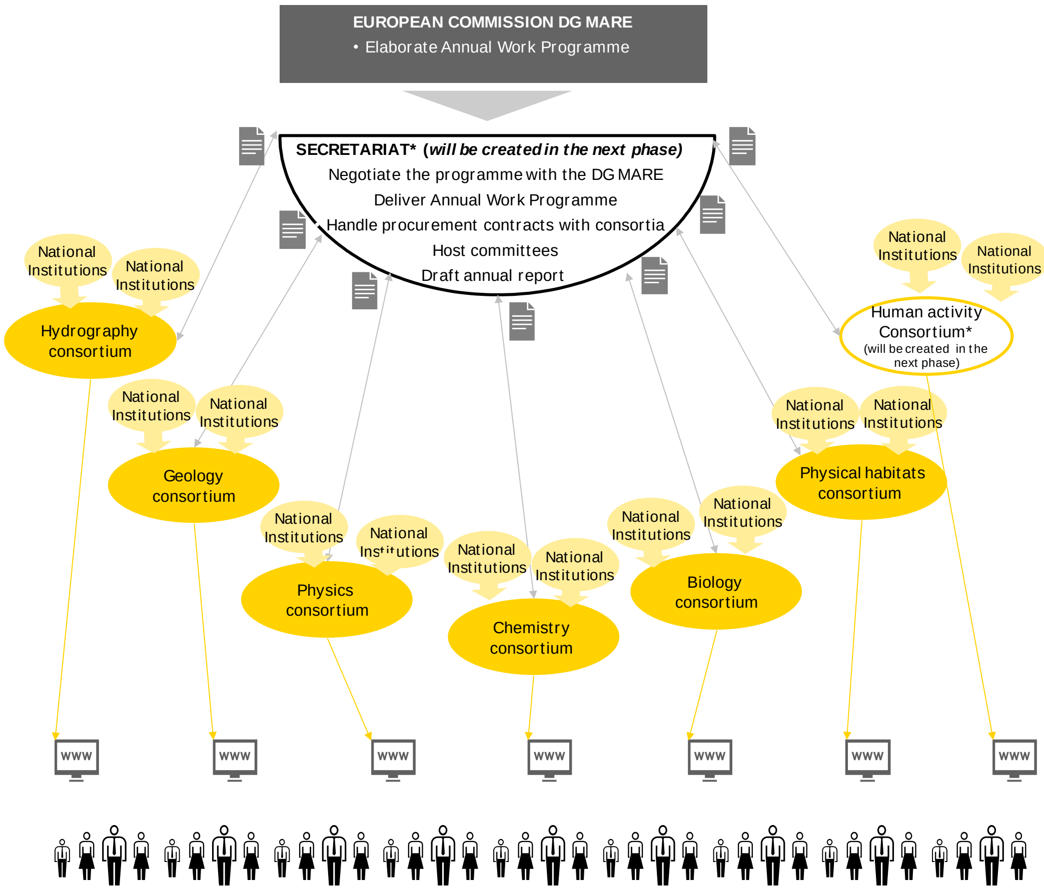
8.1.1 The secretariat

Organisation

The figure below presents the EMODNet organisation and the role of the secretariat in providing funding to a group of organisations based on an annual work programme in initial 6 and now 7 fields.

[230] This is subject to approval of the next financial perspective 2014-2020 and of the budgets and programmes as proposed by the Commission.

Figure 9 EMODNet Organisation



Currently the secretariat is being managed directly by DG MARE using an external contractor to monitor the EMODNet projects, disseminate the EMODNet results and to collect feedback and statistics on EMODNet use by users.

DG MARE is carrying out the tasks related to the programming of EMODNet (political responsibility) and contracting of the portals (funding tasks).

Budget

In the 2012 road map it is mentioned that the Commission proposes an annual budget of EUR 30 Million[231]. The annual budget includes the secretariat and the fund to be disbursed. The funding will be disbursed in line with the financial regulation e.g. call for tender, call for proposal or in a different way.

8.2 Description of governance options

The governance of the European Marine Observation and Data Network is carried out through the secretariat presented in the previous Chapter. This section looks at

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[231] This is subject to the final decision on the multiannual finance framework and may be subject to revision by the Commission.

the different options to organise the secretariat and available opportunities in the EU financial regulation.

8.2.1 Keeping the secretariat in the Commission

The Commission can consider full or part internalisation of the programme. This implies that the secretariat aspects of the programme will be performed in-house by the Commission. DG MARE is the "owner "of the programme and would be the most obvious candidate to manage the secretariat. In this option all the functions of the secretariat would have to be undertaken by DG MARE staff members.

It could also be envisaged that the secretariat be placed in another Directorate-General or Service of the Commission (e.g. DG MOVE, DG ENV or the Joint Research Centre - JRC), in case there are possible synergies in doing so (e.g. centralised contract and finance management or thematic relevance). Nevertheless, as maritime affairs are one of the main policy areas of DG MARE, it is considered the most relevant Commission service to retain responsibility of EMODNet.

8.2.2 Executive Agencies

Executive agencies under the European Commission are relatively new Commission structures governed by Framework Regulation (EC) No. 58/2003 laying down the statute of Agencies. The role of an Executive Agency is to assist the Commission in the management of EU programmes. This implies implementing Community programmes partly or fully. The Agencies are established by the Commission and can only operate within the area entrusted to them. The Agencies may not have any political or programming tasks as these tasks lie with the Commission. The main objective of out-sourcing management tasks to Executive Agencies is to achieve the goals of Community programmes more effectively and in a cost efficient manner.

Existing Executive Agencies

At present, there are 6 Executive Agencies:

- European Research Council Executive Agency (ERC Executive Agency)
- Research Executive Agency (REA)
- Executive Agency for Competitiveness and Innovation (EACI)
- Trans-European Transport Network Executive Agency (TEN-T EA)
- Executive Agency for Health and Consumers (EAHC)
- Education, Audiovisual and Culture Executive Agency (EACEA)

The existing Executive Agencies have the following characteristics. REA and ERC Executive Agencies implement research programmes under the supervision of DG Research and Innovation. EACEA implements programme strands in the fields of education and training, active citizenship, youth, audiovisual and culture. The parent DG of EACEA is DG EAC as well as DG INFSO for the media programme. EAHC is under the supervision of SANCO dealing with programme implementation under public health, food safety and consumer affairs. The TEN-T EA is dedicated to transport infrastructure projects to ensure technical and financial implementation and management of the TEN-T projects funded by the TEN-T Programme. Finally, EACI is dedicated to the management of energy, transport, environment, competitiveness and innovation and reports to DG Energy, DG Mobility and Transport, DG Enterprise and DG Environment.

An example

An example of programme implementation by an Executive Agency is the Marco Polo project, which runs until 2013. It aims at reducing road congestion and pollution by promoting a modal shift to greener transport modes for European freight traffic[232]. To attain this goal, the agency is co-funding direct modal-shift or traffic avoidance projects in the form of grants. While DG MOVE has the overall responsibility, EACI is managing the operational side of the programme.

EMODNet

Programme responsibility for EMODNet, including policy decisions, remains with DG MARE, whereas all operational tasks (including tendering, contracting and monitoring) are undertaken by an existing agency. The agency may use its own staff for the functioning of the secretariat or contract new staff as required. In addition, the EMODNet secretariat would benefit from synergies and sharing of back-office functions with the already existing structures of the agency. As Executive Agencies are based in Brussels with the exemption of EAHC, they are in physical proximity to the offices of DG MARE.

8.2.3 Regulatory agencies

A number of specialised and decentralised EU agencies have been established to support the EU Member States. These agencies are an answer to a desire for geographical devolution and the need to cope with new tasks of a legal, technical and/or scientific nature. Regulatory agencies have a variety of specific roles, set out in their own legal basis, case-by-case.

The regulatory agencies can be categorised roughly on the basis of their functions:

› adoption of individual decisions;

› technical or scientific advice to the Commission and the Member States;

› responsibility for operational activities;

› information and networking services;

› services to other agencies and institutions.

[232] http://ec.europa.eu/transport/marcopolo/about/index_en.htm

The specific roles of each agency are set out in its own founding legal act. These agencies are independent bodies, usually governed by a Management Board. The Management Board has responsibility for overseeing the performance of the agency and for nominating the Director, who in turn is in charge of the agency's operational aspects. Most of the agencies are funded by the EU budget, and hence the European Parliament has responsibility for their budgetary discharge. In addition, the general Financial Regulation, along with the Framework Financial Regulation, provides common rules for the agencies' financial governance.

Among the existing regulatory agencies, the ones listed below appear to be the most relevant for EMODNet as far as thematic area is concerned:

› The European Maritime Safety Agency (EMSA). EMSA's mission is to "reduce the risk of maritime accidents, marine pollution from ships and the loss of human life at sea"[233]. Besides monitoring the implementation of relevant EU legislation, EMSA develops and operates maritime information networks (e.g. SafeSeaNet, EU LRIT).

› The European Environment Agency (EEA). EEA's mandate is to "help the EU and member countries make informed decisions about improving the environment, integrating environmental considerations into economic policies and moving towards sustainability"[234].

These two regulatory agencies co-operate with other bodies and sources for the collection and dissemination of data (e.g. the European Space Agency in the case of EMSA, or the European Network for the Implementation and Enforcement of Environmental Law (IMPEL Network) in the case of the EEA).

In this option, programme responsibility for EMODNet, including policy decisions, remains with DG MARE, whereas all operational tasks (including tendering, contracting and monitoring) are undertaken by an existing agency.

8.2.4 Align EMODNet with other research initiatives

To stimulate research and economic development, the EU has set up special partnership bodies to work with the private sector and provide funding. Examples of such bodies involving joint undertakings include; ITER for nuclear fusion and SESAR for air traffic management, the Joint Technology Initiatives under the 7th Framework Programme, the Joint Programming Initiatives started in 2008 and the European Institute of Innovation and Technology (EIT).

Arrangements for the financial and administrative governance of these bodies are governed by rules under the Financial Regulation, and they are directly responsible to the discharge authority for budget implementation. Like the Executive Agencies, political or programming activities can not be outsourced to Joint Initiatives.

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[233] http://emsa.europa.eu/about/what-we-do-main/mission-statements.html
[234] http://www.eea.europa.eu/about-us

Two notable examples of Joint Initiatives have been identified in this category:

- *The European Earth observation programme Copernicus*, previously known as GMES (Global Monitoring for Environment and Security)[235]. Copernicus collects information in six areas (land, marine, atmosphere, climate change, emergency management and security) through earth observation satellites and *in situ* sources (like ground, airborne and sea-borne sensors) as well as disseminating information and data. Copernicus is supervised by a council and the management of the Fund is entrusted to the Commission in accordance with the Financial Regulation. The development of the observation infrastructure is delegated to the European Space Agency for the space part and of the European Environment Agency and the Member States for the in situ part. For maritime topics, the information is made available free of charge through the EU-funded MyOcean2 project [236].

- *Joint Programming Initiative on Healthy and Productive Seas and Oceans* (JPI Oceans)[237]. The goal of JPI Oceans is to provide a long term platform where Member States can better plan and cooperate their marine and maritime-related research activities and also allow for better exchange of information and best practices. Its governance includes a Management Board, an Executive Committee and a Strategic Advisory Board**.** A secretariat is responsible for the day to day management of JPI Oceans. Currently JPI Oceans has 18 participating countries: Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Italy, Lithuania, The Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Turkey and the United Kingdom. The European Commission participates as a non-voting member of the Management Board.

In transferring the secretariat to one of these bodies, DG MARE would retain the political responsibility of the EMODNet Programme. A Joint Initiative could then make use of its own secretariat, or develop a dedicated secretariat structure or cell depending on its specific, existing governance structure and procedures.

8.2.5 Private Public Partnership (PPP)

Public Private Partnerships (PPPs) are forms of cooperation between public authorities and the private sector and used quite often in the area of infrastructure and public services. They are considered to combine the benefits of the private and the public sector by providing an effective way to attain the planned goals, by encouraging innovation and ensuring the long term viability of projects. In some circumstances PPPs may deliver better grant-funded projects than classical

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[235] http://copernicus.eu/
[236] http://www.myocean.eu.org/
[237] http://www.jpi-oceans.eu/

procurement, while in some cases the alternative to a PPP might be no project at all[238].

Today, there is a wide range of experiences with the use of PPPs in various EU Member States, which differ between sectors and individual countries. Examples of PPP projects include the transport sector (roads), construction of public buildings (schools) and environmental infrastructure (waste treatment).

EU Funds can be combined with PPPs in a variety of ways, of which co-financing is the only one. The European Commission has made three different groups of instruments available to PPPs:

- Financial engineering instruments (LGGT and JESSICA);
- TEN-T Funds;
- Structural Fund grants.

According to the provisions of Article 63 of the new Financial Regulation[239], the Commission by way of exception may entrust tasks relating to the implementation of Union funds, including payment and recovery to bodies governed by private law with a public service mission, or to bodies, governed by the private law of a Member State and entrusted with the implementation of a PPP so long as they provide adequate financial guarantees. However, point 2 limits the tasks that the Commission may entrust to external private sector entities or bodies that do not have a public service mission. These are:

- Technical expertise tasks;

- Administrative, preparatory or ancillary tasks involving neither the exercise of public authority nor the use of discretionary power.

Given that Joint Undertakings, as described above, can be a form of PPP depending on their structure, these options consider the setting up of a new dedicated PPP form for the sole purpose of providing the secretariat of EMODNet.

Any PPP option under consideration would necessarily be subject to and limited by the provisions of Article 63 of the Financial Regulation as described above. This means that the number and extent of tasks that DG MARE will be able to externalise to a PPP structure would not include the political responsibility of the Programme.

Further, the current secretariat set-up is being run on the principles of providing data to the public at marginal costs. This was a request made by the user community at the time of the 2010 consultation. A PPP model would mean running

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[238] EIB, The EIB's role in Public-Private Partnerships (PPPs), http://www.eib.org/attachments/thematic/eib_ppp_en.pdf.
[239] Regulation 966/2012 on the financial rules applicable to the general budget of the Union and repealing Council Regulation 1605/2002, OJ L 298/1 26.10.2012

the secretariat at marginal costs, as well as gaining a profit margin for operators by charging users of EMODNet.

8.2.6 Fund disbursement

The Financial Regulation provides different options for the disbursement of funds and programming through calls for tenders, calls for proposals and funding of specific organisations.

Furthermore, EU funds can be disbursed through different types of management depending on the nature of the funding:

› Shared management refers to the implementation of structural policies e.g. agriculture, regional, etc.

› Centralised Direct Management (centralised indirect management of agencies etc). This is typical for internal policies.

› Research. Research management is common for the research budget managed by DG RTD and DG INFSOC.

› External management relates to the EU budget for external actions and policies including aid and trade.

In the current situation, the funding of EMODNet is done under direct management procedures, through the procurement of services by an external contractor for both the secretarial tasks and the management of the portals.

The method of fund disbursement will depend on the individual option:

› for the full internalisation or for retaining the existing situation, direct management will be applicable;

› in an Executive Agency the director implements the corresponding operational appropriations under direct management;

› for the regulatory option, the Commission may transfer the necessary funds to the agency through a grant, with the latter disbursing the funds according the agreed terms of reference and the Financial Regulation.

› for the Joint Initiatives, the exact nature of the funding option will depend on the exact structure and prior agreements with the Joint Undertaking. This can be either through direct or indirect management. This option, due to the nature of the Joint Initiatives, allows for the possibility of additional funding to be provided by the Member States or other partners;

› For the PPP option, the indirect management procedures will have to be followed as described in Article 58 of the Financial Regulation.

8.3 Assessment of secretariat options

In the following we look at organisational and administrative aspects of the secretariat followed by efficiency and cost of running the secretariat. Finally in Chapter 8.3 we sum up the main findings and recommendations.

8.3.1 Operational and organisational issues

Financial regulation

According to the Financial Regulation, the DGs of the Commission must always be responsible for tasks that are concerned with:

- i) defining objectives, strategies and priority areas of action,
- ii) adopting work programmes serving as financial decisions, and specific financing decisions,
- iii) representing the Commission in the Programme Committee and the submission of measures to be taken where there is a comitology procedure,
- iv) undertaking inter-service consultations with the Commission,
- v) activities involved in launching and taking enforceable recovery decisions. Those tasks are expressly excluded from any possible externalisation discussions.

Other tasks may be externalised, but the degree to which this is permitted will depend on the **nature** of the body to which they are being confided.

The financial regulation provides an option for a limited externalisation to the private sector. However, private sector contractors cannot undertake any tasks forming part of the public service mandate, which concretely translates into the fact that they cannot make contracts or handle money on behalf of the Commission.

There are no obvious legal impediments concerning Agencies and Joint initiative solutions. However, Executive Agencies were expressly created to be part of the Commission's public service mission and to assist and manage the implementation of programmes for the Commission.

Table 8-2 Task allocation to different identities

Hypothetical tasks	Regulatory Agency	Executive Agency	Joint undertaking	Private contractor
Preparation and publication of calls for proposals based on the priorities set out in the working programme	all	all	all	Part only
Awarding grants	all	all	all	None
Preparation and signature of contracts and subsequent management of contractual arrangements	all	all	all	None
Monitoring of projects, including potential site visits and assessments of reports and deliverables	all	all	all	all

Content and objectives of the programme

The EMODNet project as analysed above deals with the collection and dissemination of data related to the marine environment and the human activities relating to it. In this respect, all of the options examined deal, in one form or another, with the gathering and dissemination of information in areas that relate to the maritime field. High similarity is attributed for EEA and the two Joint Initiative projects, as the collection of data for the maritime area is within their main tasks. EMSA is more focused on maritime safety issues, while the Executive Agencies are mainly focus on programme implementation (which is the aim of the secretariat).

Project management cycle

EMODNet is expected to run during the next financial perspective of 2014-2020. All of the options above are (or are expected to be) familiar with the management of multi-annual projects. While for most of the options this is done on an ad-hoc basis, the Executive Agencies have dedicated structures and expertise, as they run calls for tenders (for multiannual contracts) every year with specific timeframes. The Commission is clearly responsible for Executive Agencies as they create them, maintains control over the activity and appoints the key staff (including having Commission staff in the agency). Eventually agencies or joint initiatives would provide the shorter management chain.

Beneficiaries

The direct beneficiaries of the secretariat are the consortia made up of public bodies and private companies and which provide the necessary data through procurement procedures.

The programme beneficiaries would be public authorities, private industry, researchers, etc. who makes use of the data in more or less processed form. One of the aims of the EMODNet is to provide these users with better and more accessible data.

If using an external provider to wrong the secretariat in a PPP option there could be a risk that the know-how will remain with the provider rather than the Commission (alternative solutions may be difficult to address) and that the provider could lock other competitors out of the market. This is not likely to happen in an agency or joint initiative option.

In evaluations of current Regulatory Agencies, Executive Agencies and Joint Initiatives the structures are perceived by outsiders (beneficiaries) to be a part of the Commission. Where private bodies are involved the issue is more complex with the potential of the Commission's visibility being diluted.

Marginal costs

In the 2012 Roadmap for European Marine and Data Network it was stressed that the data should be available at a marginal cost, which means that the data distributed through the internet should be free of charge. The current "pilot EMODNet" as presented above is based on this approach, stating that:

"All the metadata and data products and most of the data are made available to users (public authorities, private industry, researchers, etc.) free of charge and free of restriction of use."

The continuation of this principle will limit the options of a PPP set-up to run the secretariat. In a PPP set-up, a user charge would cover the marginal cost of running the secretariat and a profit margin for the operator.

In the Commission and Agency options the secretariat is more likely to be run in a manner that provide basic data products at marginal costs and without restrictions of use.

Experience of Executive Agencies

In the 2009 Court of Auditors' report on executive Agencies it is argued that Executive Agencies have proved beneficial in providing service in terms of guidance to beneficiaries, communication of projects' results, reduced time for contracting, more rapid approval procedures for technical and financial reports, lower payment delays, etc. and thereby proving them as a tool to manage the implementation of programmes for the Commission.

8.3.2 Administrative and costs issues

Size of the secretariat

It is important to consider the size of the secretariat and the resources intended to be used for the governance of the marine knowledge programme. When looking at the different organisational options the administrative and horizontal costs (also to ensure alignment with the principles of sound financial management) might outweigh the benefits in smaller organisational set-ups.

DG MARE indicated that in the case of the Executive Agency option, two to three persons or Full Time Equivalent (FTE) would be envisaged to work with EMODNet in the agency, as well as two to three persons in DG MARE.

This is a relatively small organisational set up and will not justify setting up a new structure such as an agency or a joint initiative in itself. The administrative and horizontal costs, as well as the timeframe to complete the required procedures (adoption of Regulations, setting up of structures) would most likely outweigh any benefits. For the same reason, the setting up of a dedicated PPP structure cannot be considered as a cost-effective option.

On the other hand, an already existing organisational structure (such as an Executive Agency), with a similar thematic mandate could host the secretariat with a relatively modest increase in administrative and horizontal costs.

In addition, the recent screening of resources by the Commission suggested that there are no strong candidates for a new Executive Agency. If new needs appear, then the starting point of the Commission will be to explore the option of extending the scope of an existing Executive Agency to cover a new programme

Budget issues

The proposed annual budget of the Commission for the EMODNet is EUR 20-30 Million. In discussions with DG MARE it was indicated that an expected 2-3% of this would be allocated for the needs of the secretariat (EUR 500-700.000 per year).

DG MARE has indicated that the staff needed to perform the functions required would be 6 persons. In the full in-house option these persons will all be employed by DG MARE, while for the Executive Agency option 2 persons will be considered for DG MARE (ensuring planning, co-ordination and the overall responsibility) and 4 persons for the secretariat tasks.

The costs for the management of the secretariat will vary depending on the option considered. For an internalised or externalised option the costs would consist of personnel costs and overhead costs and calculations are based on annual averages.

Average staff costs and overheads in the Commission

The following cost figures for planning origins from DG Budget[240] and concerns the budget year 2011.

› For the overhead costs a value of EUR 23,000 per year per person is considered for the. This includes housing costs, IT, etc.

› A standard cost of EUR 104,000 per year per person is considered for permanent officials and temporary agents and EUR 41,000 per year per person for staff with Contract Agent status.

Calculations

For the purpose of this report it is assumed that each person is employed 100% of his/her work time. Of course, personnel might be allocated less time to EMODNet tasks (e.g. 50%) by sharing responsibilities with more colleagues. As this forms part of internal work and management decisions, these options have not been included in the analysis.

Table 8-3 Simulation of administrative costs

	DG MARE	Executive Agency

[240] Mid-term evaluation of TEN-T EA, July 2012, DG MOVE

	DG MARE	Executive Agency
No of (FTE) official and temporary agent	4	2
No of (FTE) contract agents	2	4
Personnel costs[241]	€ 498 000	€ 372 000
Overheads[242]	€ 138 000	€ 138 000
Total cost	€ **636 000**	€ **510 000**

The difference in administrative cost between the two options derives from the composition of staff categories. An Executive Agency has the possibility of staffing and retaining contract agents whereas the Commission can only retain contract agents for a limited time period. However in both options tasks related to policy making (e.g. programming, planning, co-ordination and the overall responsibility) remains with Commission officials either in the Commission or management positions in the Executive Agency. In the Executive Agency option it is assumed that 2 FTE Commission will be needed in DG MARE.

As the same staff regulations and financial regulations apply it is a fair assumption that in the case of a regulatory agency or a joint initiative the costs will be similar and most likely in between these two options.

Given the relative low number of personnel involved in EMODNet secretariat, the financial benefits of the various options do not vary significantly, so as to be able to point to a clear option. Rather, other elements, such as co-ordination and synergies might prove more important.

8.3.3 Conclusion

The focus of the governance chapter was on the qualitative analysis of the identified secretariat options in an effort to uncover the advantages and disadvantages of each one according to a number of parameters.

A limited quantitative assessment was undertaken due the limited number of staff planned to be involved in the governance as well as the limited operational budget.

In summarising the findings and recommendations the following conclusions can be drawn:

› **Full internalisation.** An internalisation of the EMODNet project would most likely centre on DG MARE. While this option would have benefits through

[241] DG MARE (4* 104,000+2*41,000), Executive Agency (2*104,000+4*41,000)
[242] Six FTE staff at the average cost of EUR 23,000.

direct control, planning and synergies, it would in most likelihood impose additional administrative and operational burdens on DG MARE;

› **Allocation of the secretarial tasks to an Executive Agency**. The role of Executive Agencies is clearly defined to manage programmes on behalf of the Commission and has proven so. EACI could be the more relevant agency to manage the secretariat based on the project management cycle and the themes of programmes dealt with.

› **Allocation of the secretariat tasks to a Regulatory Agency.** A Regulatory Agency could manage the secretariat. The more relevant agencies would be EEA or EMSA based on thematic and operational characteristics. However the mandates and tasks of Regulatory Agencies go beyond what is needed to run the secretariat and may prove to be more cumbersome in administrative terms. The Executive Agency model is more aligned to the direct needs of the secretariat.

› **Other options (Joint Initiatives)**. Of the other options examined the Joint Initiatives appear more appropriate model. Especially Copernicus was an example of a relevant organisation to manage not only the secretariat but the programme in terms of thematic expertise and content of tasks. There seems to be possibilities of achieving synergies between EMODNet and the maritime part of Copernicus as the programme beneficiary group may to a large part be identical.

› **Private entities.** It was found that the value added of EMODNet is in providing the data (gathering, monitoring and basic processing) without restrictions and at marginal costs (as a public good). This and operational limitation in the financial regulation limits the attractiveness of having a private entity running the secretariat. It is envisaged that private entities can utilise the data provided by EMODNet and benefit from further processing it.

Overall, based on the relative limited size of the secretariat it is recommended that it should be placed in close proximity to the parent DG, in this case DG MARE, either internally in the DG or in an Executive Agency. One alternative option would be to assess if there are synergies with the maritime part of Copernicus and if merging the programme into Copernicus could benefit the implementation of both programmes.

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Appendix A Off-shore wind farm data

Site specific marine biological surveys for EIAs and monitoring parameters for offshore wind farms

A.1 Introduction

This Appendix describes the results of detailed review of existing EIAs, monitoring reports and guidelines on offshore wind farms from different member states. The aim of the review has been to:

- Get information on marine biological data usually required for planning, building and operating offshore wind farms in Europe
- Get detailed information on types of investigations, methodology and scope of investigations for site specific marine biological data required in the different Member States (such as, number of samples of different, number of sampling sites etc.)

Based on this and knowledge of expenditure of time and typical costs of different types of investigations and knowledge on differences in salaries and costs in different countries as well as information from questionnaires (from Germany and UK).

A.2 EAST ANGLIA ONE, UK

A.2.1. Background

A.2.1.1. Operator

East Anglia Offshore Wind Limited has been awarded a licence to develop East Anglia One wind farm.

A.2.1.2. Characteristics of farm

The planned East Anglia ONE wind farm site is located approximately 43 km east of the Suffolk coast , UK and covers an area approximately 300 km^2.

A.2.2. Biological field surveys carried out during baseline study for the EIA

An EIA has been prepared and the following site specific biological field surveys were carried out in connection with the preparation of the baseline for the EIA:

- Benthic fauna survey
- Fish survey

- Birds and marine mammal survey

A.2.2.1. Benthic fauna

The following site specific field surveys were carried out:

- Quantitative sampling of benthic fauna. During the period 20th September 2010 to 7 January 2012 grab samples of benthic fauna was collected at 108 sites. Three samples were collected at each site. The samples were obtained using a 0.1 m^2 mini-Harmon grab. Samples were sorted, identified to species and counted in the laboratory. Biomass of major groups determined (Annelida, Crustacea, Mollusca, Echinodermata, miscellaneous groups). The data was analysed using multivariate statistics (cluster analysis, MDS ordination SIMPER analysis, ANOSIM). Habitat maps were prepared

- Seabed imagery at 19 camera and grab stations. Video imagery and multiple still seabed images were acquired from each of these stations together with a 0,1 m^2 mini-Hamon grab. All imagery was obtained using an underwater camera lowered from a vessel. 5-10 still images and 5-10 min video were taken during each camera deployment.

- Epibenthic sampling and analysis. 20 trawl samples were collected at 20 sites during the period 23 August -4 September 2010. Each trawl sample was obtained with a 2m scientific beam trawl. Catch photographed and fish and invertebrates caught were sorted, identified, enumerated and weighed on board the vessel

A.2.2.2. Fish

Site specific Fish Surveys were carried during the period 14-19. November 2010 and 16-20. February 2011. A commercial trawl was chartered for the fishery. The following trawl sampling was carried out during the two periods:

- For demersal fish:

    - Otter trawl sampling at 13 sites within the East Anglia ONE site and at 5 control locations outside the site. CPUE (individuals/hour) was estimated for each species caught.

    - Beam trawl sampling at the same 18 sites. CPUE (individuals/hour) was estimated for each species caught

- For **pelagic fish** (target species herring)

    - Pelagic trawl sampling at 9 sites in order to assess the potential presence of spawning herring in the area immediately south of the East Anglia ONE site. The sex, length and spawning condition of each individual of herring was determined (spawning condition was assessed from maturity stages of testes and ovaries using a nine stage maturity key. By catch species were also identified and counted

A.2.2.3. Birds and marine mammals

The following site specific surveys of birds and marine mammals were conducted:

› Aerial bird and marine mammal surveys of the overall distribution, density and population size of birds, seals and porpoises by high resolution digital still photo aerial survey undertaken monthly over an 18 month period from April 2010 to October 2011 (18 days of flight time). The survey area for East Anglia ONE comprised the wind farm site area together with a 4 km buffer zone around it.

› Boat based bird and marine mammal surveys over an 18 month period (subject to weather conditions) from May 2010. The surveys were undertaken through a series of transects running east to west across East Anglia ONE at a distance of 2.5 km from one another. A 4 km buffer around East Anglia ONE site boundary to the north, south and west will also be included within the transects. The surveys were undertaken using a team of four experienced surveyors

› Passive acoustic monitoring (PAM) of cetaceans initiated in July 2010 to compliment the visual observations, for period of six months PAM is only able to detect vocalising cetaceans which pass within the detection range of the hydrophone and so is not as reliable as visual observations.

A.2.3. Biological monitoring

Monitoring activities has not been initiated yet and a monitoring programme has not been published.

A.2.4. Cost estimate

A cost estimate of these activities is given in the table below.

	Cost €
Benthic fauna studies	260,000
Fish studies	90,000
Bird studies	315,000
Marine mammal studies	315,000
Total	980,000

A.3. SEAGREEN PHASE 1, UK

A.3.1. Background

A.3.1.1. Operator

Seagreen phase 2 is planned by Seagreen Wind Energy Limited which is a joint Venture between SSE Renewable Developments UK Limited and Flour 'Limited.

A.3.1.2. Characteristics of farm

Seagreen is seeking to construct and operate two offshore wind farms known as Seagreen Alpha and Seagreen Bravo. Each of the two offshore wind farms will accommodate up to 75 wind turbine generators with the potential to generate up to 525 MW of power. Project Alpha will occupy and era of 197 km^2 and Project Bravo 194 km^4. The wind farms will be situated 27-38 km east of the Scottish East coast.

A.3.2. Biological field surveys carried out during baseline study for the EIA

An EIA has been prepared and the following site specific biological field surveys were carried out in connection with the preparation of the baseline for the EIA:

- Sediment quality survey
- Benthic fauna and demersal fish studies
- Bird and marine mammal studies.

A.3.2.1. Sediment quality

A total of 50 grab samples were collected and analysed for contaminants.

A.3.2.2. Benthic fauna and fish studies

The following benthic fauna and fish surveys were conducted during the period: 2010-2012:

- Grab sampling of benthic fauna on 150 sample stations. 100 of these samples were analysed for infaunal identification
- Benthic trawl survey using a 2m wide beam trawl at 50 sites for analysis of epibenthic species and demersal fish species
- Drop down video-survey at 50 sites in approximately the same locations as the epibenthic trawls

A.3.2.3. Bird and marine mammal studies.

Bird and marine mammal surveys were carried out during the period 2009-2011. The following surveys were conducted

- Bird and marine mammals counting from boat was carried out on a monthly basis during period of two years (i.e.24 surveys) months in an app 500 km^2 area

- Aerial survey of birds and marine mammals in an app500 km^2 area carried out between May 2000 and April 2010

A.3.3. Biological monitoring

The EIA report was finalised in September 2012. Monitoring activities have not been initiated yet and a monitoring programme has not been published.

A.3.4. Cost estimate

A cost estimate of these activities is given in the table below.

	Cost €
Benthic fauna studies	80,000
Fish studies	80,000
Bird studies	270,000
Marine mammal studies	270,000
Total	700,000

A.4. OFFSHORE WIND FARM EGMOND AAN ZEE, Netherlands

A.4.1. Background

A.4.1.1. Operator

The operator of the offshore wind farm Egmond aan Zee in the Netherlands is the Nuon-Shell consortium “NoordzeeWind”.

A.4.1.2. Characteristics of farm

The wind farm is situated between 10 and 18 km off the Dutch coast west of Egmond aan Zee and covers an area of 40 km^2. It was built in 2006 and became fully operational at the beginning of 2007. It has a capacity of 108 MW generated by 36 turbines. There is a 500 m safety exclusion perimeter zone which will be closed to all shipping.

The wind farm is a demonstration project for gaining knowledge and experience for future large scale wind farms at sea. The environmental studies were carried out by the National Institute for coastal and Marine Management (RIKZ) which is a part of the 'Directorate General of Public works and Water Management

A.4.2. Biological field surveys carried out during baseline study for the EIA

Baseline field surveys was carried out in 2003-2004 and comprised:

- Benthic fauna studies
- Fish studies
- Bird studies.
- Marine mammal studies.

A.4.2.1. Benthic fauna studies

Benthic fauna survey was conducted between 22 and 31 May 2003. The survey included the collection of benthic fauna samples using box core and dredge sampling.

- Box core samples using a 0.068 m^2 box core sampler was collected at 126 sites (a total of 238 samples were collected).
- Dredge samples were collected at 51 dredge sites were larger (100 m^2) more deeply penetrating samples were collected.
- In the lab particle size and organic matter content of sediment were determined. The fauna was sorted, identified and enumerated. Data were analysed statistically using the following statistics: Shannon-Wiener index, Pielous evenness, ANOVA, Kruskal-Wallis, Scheffe post hoc, Dunnes procedure and Cluster analysis using PRIMER software.

A.4.2.2. Fish studies

Site specific fish studies were carried out in 2002 and 2003 including:

- Hydro-acoustic survey of pelagic fish and trawling for validation in June 2002 (7 work days), April 2003 (7 work days), October 2003 (4 work days). A total distance of 980 nautical miles was surveyed and a total of 81 trawl hauls were done.
- Beam trawl sampling for demersal fish was carried out during the periods 23 June - 4 July 2003 and 19-30 January 2004 (18 work days). A total of 84 transects were trawled. The haul duration at each transect was 15 minutes with an average speed of 3.5 knots. Fish were identified to species and counted . Biological data were collected from selected individuals (length, weight, sex, maturity and otholits). Catch per unit effort for each species were determined

and the following statistics were calculated: Ordination using Conoco 4.5, Redundancy analysis, power analysis**.**

A.4.2.3. Bird studies

Bird counting from ship was carried out nine times during the period 7 April 2003 - 19 February 2004. An area of 239- 486 km^2 (mean 390 km^2) was surveyed each time: a total of 3134 km^2 during the eight surveys. Four bird counters participated during each survey. Total workdays 30

A.4.2.4. Marine mammal studies

The following studies on marine mammals were conducted

- Tagging of 12 Harbour Seals with satellite transmitters for 90-227 days in order to define the use of the area by seals
- Surveys of Harbour porpoise including**:**
  - Acoustic monitoring of harbour porpoise at 8 fixed stations using 8 permanently deployed T-PODs equipped with a CTD, that detects and logs echolocation clicks from harbour porpoises and other cetaceans. The T-PODS were deployed 3. June 2003 and retrieved 25-25 May 2004. The T-PODS were serviced three times during this period.
  - Ship-based surveys carried out 8 times during the period 23 September 2002 -19. February 2004. The total durations of the surveys were 28 days.

A.4.3. Biological monitoring

In order to assess the impacts of the wind farm the following monitoring activities were carried out:

- Monitoring of benthic fauna
- Underwater acoustic measurements
- Monitoring of pelagic and demersal fish
- Monitoring of birds
- Monitoring of marine mammals

A.4.3.1. Benthic fauna

Benthic fauna monitoring was conducted 20-26 March 2007 a few months after the completion of the wind farm. The survey included the collection of benthic fauna samples using box core and dredge sampling i.e.:

- Box core sampling of macrobenthos at 60 sites using a 0.078 m^2 box core sampler

- Dredge sampling of macrobenthos at 18 sites

In addition the following surveys were conducted:

- Box core sampling of juvenile bivalve species in October 2006 using a 20 x 30 cm box core sampler in order to assess the impact on bivalve recruitment. Samples were collected at 70 sites. Current meter, fluorescence and turbidity sensors, and CTP were deployed.

- Videorecordings of monopiles and rocks of the scour protection layers were taken on 17-18 February 2011 and 24-25 September 2011. in order to monitor the development of flora and fauna on the hard substrates after completion of the wind farm. In additions Samples of organisms present on the monopoles and rocks were collected. Organisms were identified and counted in the laboratory. biomass was also determined

- In the lab particle size and organic matter content data were determined. Fauna sorted, identified and enumerated. Data were analysed statistically using the following statistics: Shannon-Wiener index, Pielous evenness, ANOVA, Kruskal-Wallis, Scheffe post hoc, Dunnes procedure and Cluster analysis using PRIMER software.

A.4.3.2. Underwater acoustic measurements

Underwater acoustic measurements using a hydrophone from a fishing vessel which was passively drifting with all equipment switched off were conducted in 2007 during three wind turbine operations.

A.4.3.3. Fish

Fish monitoring was carried out in 2007 and 2008 after the construction of the farm. The fish monitoring/study included:

- Hydro-acoustic survey of pelagic fish and trawling for validation during the period 4- 20 April 2007 (13 work days). A survey was planned for spring 2011, but it has not been possible to get information on this survey

- Beam trawl sampling was carried out in June 2007 (10 work days) and January 2008 (10 work days). A total of 40 transects were trawled during each survey. A survey was planned for January 2011, but it has not been possible to get information on this survey. The haul duration at each transect was 15 minutes with an average speed of 3.5 knots. Fish were identified to species and counted. Biological data were collected from selected individuals (length, weight, sex, maturity and otholits). Catch per unit effort for each species were determined and the following statistics were calculated: Ordination using Conoco 4.5, Redundancy analysis, power analysis.

- Tagging and telemetry experiments with cod and sole in order to study the potential effects of wind farms on fish behaviour

A.4.3.4. Birds

The following bird monitoring activities were conducted

- Ship counts of birds along 10 transects (A total length of 250 nm, area 800 km^2), during the period April 2007 - Nov 2009 to assess the distribution patterns of local seabirds. A total of 17 surveys were conducted during a total of 51 days

- Assessment of flight paths of birds flying through the wind farm by visual observation and by fully automated radar observations visual observations were carried out during the period 21 February2007- 16 December 2010. Observations were carried out for a total of 53 days and 6 nights. Radar observations were carried out during the period April 2007 - 31 May 2010.

A.4.3.5. Marine mammals

The following marine mammal monitoring activities were conducted:

- Tagging of 24 Harbour Seals with satellite transmitters in the spring 2007 after the construction phase and 20 in the autumn 2007 in order to assess the use of the area by seals and to assess any impacts of the wind farm on the seals

- Acoustic monitoring of harbour porpoise at 8 fixed stations using 8 permanently deployed T-PODs equipped with a CTD, that detects and logs echolocation clicks from harbour porpoises and other cetaceans. The acoustic monitoring was carried out during the period June 2007 -April 2009. To investigate the potential effect of the wind farm a statistical before -after-control (BACI) analysis was carried out

A.4.4. Cost estimate

A cost estimate of these activities is given in the table below.

	Cost planning phase €	Cost construction phase €	Cost operation phase €
Benthic fauna	200,000	No survey	200,000
Fish	200,000	No survey	190,000
Birds	200,000	No survey	575,000
Marine mammals	650,000	No survey	325,000
Total	1,250,000	No survey	1,290,000

A.5 BIOLOGICAL MONITORING, Belgium

A.5.1 Background

A monitoring programme for two wind farms in Belgium has been undertaken in order to assess environmental impacts: The C-Power wind farm on the Thorntonbank and the Belwindfarm.

The C-Power wind farm has 60 windmills with a capcity of 325 MW and is located at 27 kilometres off Zeebrugge. The park is situated in water of 12 to 27 metres deep and the turbines are installed in an area of 18 km² in size.

The Belwind wind farm with a capcity of 330 MW is located 42 kilometres off the coast of Zeebrugge. The parkis built in water of 20 to 35 metres depth and the turbines are installed in an area of 35 km² in size.

As stipulated in the environmental permits, MUMM (Management Unit of the North Sea Mathematical Models of the Royal Belgian Institute of Natural Sciences started a monitoring programme around to estimate the positive and negative effects of the windmills at sea. Different aspects were monitored at the two sites.

A.5.2 Biological monitoring carried out

In order to assess the impacts of the wind farms the following monitoring activities were carried out:

› Monitoring of benthic flora and fauna

› Monitoring of fish

› Monitoring of birds

› Monitoring of marine mammals

A.5.2.1 Benthic flora and fauna

The following benthic flora and fauna monitoring was carried out during the period 2005 - 2011:

› Monitoring of biofouling on foundations of C-Power wind farm and Belwin during the period September 2008-November 2011. Quantitative samples of fouling organisms were collected 13 times at C-Power and 9 times at Belwin, during 17 sampling days. Subtidal samples were collected by a SCUBA diver scraping the fouling organisms with a putty knife from a sampling surface area of 0.25 x 0.25 m. two to six replicates were collected during each sampling event. A total of 111 replicate scrape samples were sampled. Videorecordings of the fouling organisms were also taken. Organisms were identified to the lowest possible taxon and counted . Densities were expressed as the number of individuals per m^2. Data was analysed statistically by the PRIMER-E software.

- Monitoring of soft sediment macrobenthos at C-Power. Van Veen grab samples were collected by SCUBA diver and Van Veen grab around turbine D5 in May 2005, in July and September 2010 and in May 2011. Three replicates were collected at each site (one for sediment analysis and two for biotic analysis). A total of 87 sediment samples and 103 fauna samples were collected. Sediment samples were analysed for grain size distribution, dry weight and total amount of organic material (TOM%). The benthic fauna in the samples were identified and counted. Data were analysed statistically by non-metric multidimensional scaling using the software PRIMER.

- Monitoring of soft sediment macrobenthos at C-Power and Belwin during the period spring 2005 - autumn 2008, 21-24 September 2009 Van Veen grab samples were collected four times. A total of 463 samples were collected visited. Sediment samples were analysed for grain size distribution, dry weight and total amount of organic material (TOM%). The benthic fauna in the samples were identified and counted. Data were analysed statistically by non-metric multidimensional scaling using the software PRIMER.

A.5.2.2. Fish

The following fish monitoring was carried out during the period 2005 - 2012:

- Monitoring of epifauna and demersal fish fauna at Belwin by trawling with shrimp trawl along twelve, 2 km long transects once in spring and autumn 2008, 2009, 2010, 2011 and 2012. Fish and epifauna were identified and counted and abundance of each species estimated estimated

- Monitoring of epifauna and demersal fish fauna at C-Power by trawling with shrimp trawl along ten 2 km long transects once in spring and autumn 2005, 2008, 2009. Fish and epifauna were identified and counted and abundance of each species estimated

- Monitoring the migration of acoustically tagged cod. 19 specimens were tracked during the period 6 August and 1 October 2010

- Monitoring of changes of fish diet at C-Power in spring 2009 and autumn 2010. Samples for stomach analyses of fish were collected at 4 sites using shrimp trawl. Line and gill net fishing for codfish for analysis of stomach content was also carried out in 2009

- Underwater census by SCUBA divers on scour protection at C-Power between July and October 2009 (9 surveys were carried out)

- Line fishing for cod fish at 7 C-power piles during the period 7 January 2009 - 6 November 2009 (9 fishing rounds were carried out). CPUE was calculated for each species

A.5.2.3. Birds

The following bird monitoring was carried out during the period 2005 - 2011:

- Monthly ship based counts of birds at C-Power wind farm and Belwin wind farm in 2005 - 2011. A total of 186 surveys were carried out at the two sites
- Test of Radar system for observation of migration of birds in 2010. The system has not yet been deployed at a wind farm.

A.5.2.4. Marine mammals

The following marine mammals monitoring was carried out during the period 2008 - 2011:

- Aerial survey of harbours porpoise and seals before and during piling operations at C-Power wind farm with a view to assess impacts of piling. Surveys were carried out During the period April 2008 - March 2011. The total duration of surveys during this period were 15days surveys 8-9 April 2008, 5 May 2008, 7 May 2008 29 July 2008, 18-19 February 2009, 14-May 2009 and 4-5 August 2009.
- Passive acoustic monitoring of Harbour porpoise using C-PoDs before and after piling operations at three sites. The C-PoDs were deployed during the period end 19 October 2009, March - May 2011
- Acoustic underwater measurements at four sites before and during piling in order to quantify the underwater noise emitted during the construction phase. Measurements were carried out 11 times during the period 2008-2011.

A.5.3.Cost estimate

A cost estimate of these activities is given in the table below.

	Cost construction phase both wind farms €	**Mean cost per wind farm**
Benthic fauna	680,000	340,000
Fish	500,000	250,000
Birds	1,500,000	750,000
Marine mammals	550,000	275,000
Total	3,230,00	1,615,000

A.6 HORNS REV I, Denmark

A.6.1. Background

A.6.1.1. Operator

Elsam A/S and Eltra A.m.b.A. established Horns Rev I offshore **wind farm** in 2002. In 2006 Vattenfall took over 60% of the farm making the company responsible for the operation of the **wind farm** and for the environmental monitoring programme.

A.6.1.2. Characteristics of farm

The Wind farm is situated 14 km west -south west of Blåvands Huk on the southern part of the West coast of Jutland Denmark. The **wind farm** is comprised of 80 2MV wind turbines. The **wind farm** covers a total area of 4 km^2 including a 200 m wide exclusion zone around the periphery of the wind farm. The water depth is 6.5-13.5 m.

A.6.2. Biological field surveys carried out during baseline study for the EIA

Baseline field surveys was carried out in 1999-2002 and comprised:

- Benthic flora and fauna studies
- Bird studies.
- Marine mammal studies.

A.6.2.1. Benthic flora and fauna studies

Benthic in fauna survey was conducted in 1999 and 2001. The following surveys were carried out:

- EIA screening spring 1999 including video survey by SCUBA diver at 80 sites. Quantitative sampling of benthic infauna at 40 stations (two replicates at each), aerial photography
- Baseline surveys of benthic infauna were conducted in June and September 2001. In June 2001, samples were collected from a total of 18 stations. In September 2001, samples were collected from 9 stations. At each station, three quantitative HAPS-samples with a surface area of 0.0123 m^2 were taken by SCUBA divers (two for fauna analysis and one for analysis of sediment characteristics). In the laboratory sediment samples were analysed for grain size distribution, dry matter content loss on ignition. Fauna samples were sieved, sorted and the animals were identified to the lowest possible taxon. The data were subject to the following statistical analysis (Multidimensional Scaling (MDS) and ANOVA

A.6.2.2. Bird studies

Aerial surveys of bird numbers and distribution in the Horns Rev area 16 times during the period 1999-2001. At each survey a total of 26 north south oriented parallel transects, flown at 2 km interval were surveyed (total lengths of transects 800 km (during one work day). Four observers participated in each survey. For all relevant species, distribution maps based on pooled data from all surveys were prepared and Jacobs sensitivity index calculated

A.6.2.3. Marine mammal studies

The following studies on marine mammals were conducted

- Line transect survey from ship of harbour porpoise each year during the period 1999-2001. Transect lay out consisted of 14 parallel lines oriented east-west and with a total length of 500 km. The transects could be completed in two days.3 observers participated in each survey.
- Acoustic monitoring of harbour porpoise at 6 fixed stations using 8 permanently deployed T-PODs equipped with a CTD, that detects and logs echolocation clicks from harbour porpoises and other cetaceans. The T-PODS were deployed 1 July 2001 and were in operation during the pre construction phase until 3. March 2002.

A. 6.3. Biological monitoring

In order to assess the impacts of the **wind farm** the following monitoring activities were carried out:

- Monitoring of Benthic flora and fauna
- Underwater acoustic measurements
- Monitoring of fish
- Monitoring of birds
- Monitoring of marine mammals

A.6.3.1. Benthic flora and fauna

During the monitoring period, infauna surveys were conducted in 2003, 2004 and 2005 i.e.

- In September 2003 and 2004, samples were collected at 24 stations
- In March-April 2005 samples were collected from 45 stations.
- At each station, three quantitative HAPS core samples with a surface area of 0.0123 m² were taken by SCUBA divers (two for fauna analysis and one for analysis of sediment characteristics. In the laboratory sediment samples were analysed for grain size distribution, dry matter content loss on ignition. Fauna

samples were sieved, sorted and the animals were identified to the lowest possible taxon. The data were subject to the following statistical analysis (Multidimensional Scaling (MDS) and ANOVA.

Monitoring surveys of hard bottom flora and fauna were performed in March and September each year from 2003 to 2005 in order to monitor the colonisation of flora and fauna on monopoles and scour protection. Surveys were performed at six turbine sites. The surveys at each turbine site included

› Collection of samples on the scour protection by SCUBA divers along a transect in the direction of the main current Three stations at distances 0.5 m, 2 m and 5 m from the monopiles were selected along the transects. As a reference, one station was additionally sampled 5 metres upstream from the monopole. At each station, samples of fouling organisms were thoroughly scraped off the stone blocks within a frame of 0.04 m² using a special scraping tool and a special underwater air-lift device. A total of 72 scour protection samples were collected during each survey.

› Collection of samples by SCUBA divers on three e monopile at three locations at depth intervals of 0 m, 2 m, 4 m, 6 m and 8 m measured from the bottom of the scour protection Two 0.04 m² frame samples were taken within each depth interval on each side of the monopile. Larger algae and shellfish as well as other fouling organisms were scraped off using the same technique used on the scour protection

› Visual determination by SCUBA diver A semi quantitative assessment was carried out on the coverage of different groups of organisms on monopoles and scour protection using the Braun-Blanquet scale .Underwater video recordings were also made for documentation.

A.6.3.2. Underwater acoustic measurements

Measurements of underwater noise were done at one site in the **wind farm** area during the period 2-5 November 2005.

A.6.3.3. Fish

Fish monitoring was carried out in 2003, 2004 and 2005 after the construction of the farm. The fish monitoring/study included:

› Test fishing was performed at a turbine site in September 2003 in March 2004 and September 2004 In order to assess the fish fauna at monopoles and scour protection. Both pelagic biological survey gill nets and sinking gill nets were used during day and night.

› Hydro-acoustic survey of fish during the periods 9-10 October 2004 and 4-6 September 2005. The hydroacoustic surveys were carried out along four transects. During the 2005 survey fishing with pelagic and benthic gill nets as well as small pelagic trawl was carried out as well

- Fishing for sandeels and shellfish using a special sandeel dredge at 12 sites in February March 2002 (5 workdays) and in March 2004 (5 workdays). The sandeels caught were identified to species, counted, measured and weighed. Maturity was also determined. The different species of shellfish caught were counted and length and weight of each individual was measured. The swept area of each dredge hauls was calculated and used to estimate relative densities of sandeel. 36 grab samples for grain size distribution analysis were sampled as well at each of the two sampling rounds.

A.6.3.4. Birds

- Aerial surveys of bird numbers and distribution in the Horns Rev area 16 times during the period 2002-2005. At each survey a total of 26 north south oriented parallel transects, flown at 2 km interval were surveyed (total lengths of transects 800 km (during one work day). Four observers participated in each survey. For all relevant species, distribution maps based on pooled data from all surveys were prepared and Jacobs sensitivity index calculated

- Radar and visual observation of birds with a view to assess avoidance behaviour and collision risk due to the presence of the **wind farm** in spring and autumn during the period 2003-2005. Observation of migratory birds was undertaken from a transformer station 560 m north of the **wind farm**. Observations were performed during a total of 19 visits to the area. In total 243 hour of visual observation and 403 hours of radar observations were carried out. The migration routes of the birds were mapped by tracing the course of bird flocks.

- Radar, visual and acoustic observations of migrating birds were carried out from anchored vessel during spring and autumn 2005. 10 trips with 35.5 effort days were carried out. In spring 67 hour of acoustic surveys during night were carried out and 297 in autumn.

A.6.3.5. Marine mammals

- Harbour seals. Tagging of 21 Harbour Seals with satellite transmitters during the period 2002-2005 in order to observe the use of the area by seals and to assess any impacts of the **wind farm** on the seals

- Line transect survey from ship of harbour porpoise each year during the period 2002-2005. Transect lay out consisted of 14 parallel lines oriented east-west and with a total length of 500 km. The transects could be completed in two days.3 observers participated in each survey.

- Acoustic monitoring of harbour porpoise at 6 fixed stations using 8 permanently deployed T-PODs equipped with a CTD, that detects and logs echolocation clicks from harbour porpoises and other cetaceans. The T-PODS operated from 18 December 2002 to 31 December 2005.

A.6.4. Cost estimate

A cost estimate of these activities is given in the table below.

	Cost planning phase €	Cost construction phase €	Cost operation phase €
Benthic fauna	190,000	No survey	280,000
Fish	25,000	No survey	150,000
Birds	180,000	30,000	410,000
Marine mammals	150,000	110,000	265,000
Total	545,000	140,000	1,105,000

A.7 NYSTED OFFHORE WIND FARM, Denmark

A.7.1. Background

A.7.1.1. Operator

Nysted Offshore Wind farm was established in 2003 by ENERGI E2 as operator. Ownership is shared between ENERGI E2, DONG and Sydkraft.

A.7.1.2. Characteristics of farm

Nysted Offshore Wind Farm is located in the Baltic Sea south of the Danish island Lolland. The nearest distance to the shore (Nysted) is 10 km. It consists of 72 wind turbines each of 2.3 MW, corresponding to a total of 165.6 MW installed power. The farm occupies an area of

A.7.2. Biological field surveys carried out during baseline study for the EIA

Baseline field surveys was carried out in 1991-2001 and comprised:

› Benthic flora and fauna studies

› Fish studies

› Bird studies.

› Marine mammal studies.

A.7.2.1. Benthic flora and fauna studies

Benthic flora and fauna surveys were conducted in 1999 and 2001 and included:

› Mapping of distribution of marine habitats and extent of and coverage of eelgrass and macroalgae based on photo sampling on 165 sites within the future wind farms site and at reference sites during the period 10-12 May

1999. The photosampling equipment consisted of a photo camera and a video camera mounted on a steel frame that is lowered to the bottom. The video is connected to a monitor a videorecorder on board the survey vessel. Extent of seagrass, algae, musselbeds and sand bottom was mapped based on a general evaluation of the photo and videorecordings and the coverage of seagrass and macroalgae estimated.

- Mapping of distribution of marine habitats and extent of and coverage of eelgrass and macroalgae based on photo sampling on 310 sites within the future wind farm site along the cable transect and at reference sites during the period 25-27 May 2001.

- Quantitative sampling of benthic fauna, sediment, common mussels and fouling organisms during the period 2-5 August 1999 within the future wind farms site and at reference sites Benthic fauna and sediment were collected at 89 sites using a 0.1 m^2 Van Veen grab (one sample at each site). The sediment samples were analysed for dry weight and loss on ignition. 'The benthic fauna samples were sorted and the animals identified to species level and counted. A diver collected 5 quantitative samples of common mussels at each of 19 sites. Biomass and condition were measured in the laboratory. Videorecordings and quantitative samples of fouling organisms were collected from a metocean measurement mast in the area mast . Data were analysed statistically using cluster analysis, MDS, BIENV, SIMPER and ANOSIM-test.

- Quantitative sampling of eelgrass and macroalgae in August 2001 by SCUBA diver at 6 and 7 sites respectively. Six samples were collected at each site. Shoot density biomass of eelgrass were determined as well as species composition and biomass of algae

- Quantitative sampling of benthic fauna and sediment along the cable transect in August 2001. Benthic fauna and sediment were collected at 20 sites using a 0.1 m^2 Van Veen grab.

A.7.2.2. Fish studies

Fish surveys were carried out during the spring 1999. The following fish surveys were carried out:

- Test fishing using gill nets and fish traps at 10 sites on 27 and 28 April 1999. Catch per unit effort were estimated for each species of fish caught

- Test trawling along 8 transects during the period 26 - 27 May 1999. Catch per unit effort were estimated for each species of fish caught

- Test fishing for adult fish and fish fry at 24 sites using specially designed (scientific) gill and fyke nets. The fishing for adults were carried out during the periods 16-27 May and 16-20 June 2001. The fishing for fry was conducted in the periods 24 -27 September, 25 -28 October and 24 -26 November 2001. Catch per Unit effort for numbers and total weight of each species were estimated

A.7.2.3. Bird and marine mammal studies

The following bird and marine mammals studies were conducted:

- Observations of migrating birds in the Rødsand area during 22 September-12 November 1999 (28 days) and during 20 March - 19 April 2000 (13 days). Observations were conducted from an observation tower placed 5 km northeast of the wind park area

- Observation of foraging movements of Cormorants from observation tower on 29 September 1999

- Aerial surveys of bird, seal and porpoise numbers and distribution in the Rødsand area 7 times during the period 9 February 1999 -4 April 2000. During each survey a 26 north south oriented parallel transects were flown (total lengths of transects 597-1176 km (during one work day). Four observers participated in each survey. For all relevant species, distribution maps were prepared

- Bird, seal and porpoise surveys from ship were carried out nine times during the periods 30 January- 12 February, 21-22 March and 17-18 August 1999. The survey included a total 25 north-south orientated parallel transects

A.7.3. Biological monitoring

In order to assess the impacts of the wind farm the following monitoring activities were carried out:

- Monitoring of benthic flora and fauna

- Monitoring of fish

- Monitoring of birds

- Monitoring of marine mammals

A.7.3.1. Benthic flora and fauna

During the monitoring period, benthic fauna surveys were conducted in, 2004, 2005 and 2006 i.e.

- Monitoring of the composition of the benthic fauna by photosampling and videorecording at 200 sites in May 2005, Qauntitative sampling by Van Veen grab (0.1 m^2) on 88 sites in August and Quantitative sampling of common mussels in 'August 2005

- Monitoring the colonisation by fouling organisms on concrete foundations, stone filling on foundations and scour protection stones by video recording, underwater photography and quantitative sampling of sessile organisms in September-October 2003 and in September 2005.

A.7.3.2. Fish

Fish monitoring was carried out in 2004 and 2005. The fish monitoring/ included:

- A static hydroacoustic survey of fish at a turbine foundation to investigate effects from foundations and turbine activity on fish behaviour during the period 11 November - 11 December 2004. The surveillance system consisted of two submerged surveillance units, a hydroacoustic surveillance unit and a shared control/data acquisition unit. The acoustic survey was supplemented with videorecordings and test fishing using "biological" gill nets

- A dynamic hydroacoustic survey of fish from a dinghy sailing along a 28 km long track on 31 October and 1 November 2004

- A Hydro-acoustic survey of fish from a large vessel during the periods 1½6-17 September and 21-23 September 2005. The hydroacoustic surveys were carried out along 6 transects with a total length of 28 km.. Supplementary fishing with pelagic and benthic gill nets as well as small pelagic trawl was carried out as well

- Test fishing with fyke nets deployed on both sides of the cable from the wind farm in order to assess any impacts on fish migration from electromagnetic fields around the cable. . Fishing was carried out from a rubber dinghy during the periods 23 September to late November, 10 August - 25 September 2002, 9 September -17 November 2003. During the fishing periods the nets were emptied every second day.

A.7.3.3. Birds

The following bird monitoring activities were conducted:

- Aerial surveys of birds numbers and distribution in the Rødsand area 25 times during the period May 2000 - November 2005. During each survey a 26 north south oriented parallel transects were flown (total lengths of transects 597- (during one work day). Four observers participated in each survey. For all relevant species, distribution maps were prepared

- Radar and visual studies of bird migration with a view to assess avoidance behaviour and collision risk due to the presence of the wind farm in spring and autumn during the period 2000-2005. Each year observations were carried during 14 March -19 April and 30 August -12 November

A.7.3.4. Marine mammals

The following marine mammal monitoring activities were conducted:

- Tagging and satellite monitoring of 4Harbour Seals and 6 Grey Seals with satellite transmitters during the period 21 April 2001 -29 April 2002 in order to observe the use of the area by seals and to assess any impacts of the wind farm on the seals

- Monthly aerial surveys of seals at hauls out sites during the period March 2002 -October 2005. A total of 48 surveys each lasting 2 hours were conducted. Two observers were employed at each survey

- Remote video monitoring of seals at a seal sanctuary (haul out site) close to the wind farm to monitor impacts of construction of wind farm. Two web based video cameras were installed in April 2002 and operated to the end of 2004. A total of 656 days of recording took place resulting in 5 million pictures which were stored and analysed

- Acoustic monitoring of Harbour Porpoise at 6 fixed stations using deployed T-PODs equipped with a CTD, that detects and logs echolocation clicks from harbour porpoises and other cetaceans From 14 November 2001 to 19 December 2005 a total of 12 different T-PODs were deployed resulting in a total of 7018 deployment days. The stations were visited around 40 times for service and deployment .

A.7.4. Cost estimate

A cost estimate of these activities is given in the table below.

	Cost planning phase €	**Cost construction phase €**	**Cost operation phase €**
Benthic fauna	190,000	No survey	230,000
Fish	145,000	No survey	75,000
Birds	250,000	125,000	460,000
Marine mammals	No survey	160,000	280,000
Total	585,000	285,000	1,045,000

A.8 KRIEGERS FLAK II, SWEDEN

A.8.1. Background

A.8.1.1. Operator

Construction of Kriegers Flak II is planned to start 2012/2013. The developer is Wattenfall in cooperation with WPD Offshore. An EIA has been prepared and permission to construct the wind farm has been issued .

A.8.1.2. Characteristics of farm

The planned construction site is situated on the north Eastern section of Kriegers Flak inside Sweden Economic Zone about 30 km south of Trelleborg Sweden. The water depth is 16-42 meters. The wind farm is planned to consist of a maximum of 128 wind turbines with a capacity of 5 MW each and covering an area of 75 km^2.

A.8.2. Biological Field surveys carried out during baseline study for the EIA

Baseline field surveys was carried out in 2000-2004 and comprised:

- Benthic vegetation and fauna studies
- Fish studies
- Bird studies.
- Marine mammal studies.

A.8.2.1. Benthic vegetation and fauna studies

Benthic vegetation and fauna surveys were conducted in 2002 and 2003. The surveys included:

- Videosurveys along five transects with a total length of 20 km in September 2003
- Quantitative sampling of benthic infauna at 20 sampling sites using 0.1 m^2Van Veen grab. Three samples were collected at each site. Samples were twice in 2002 and twice in 2003. Data were subject to cluster analysis and multidimensional scaling analysis

A.8.2.2. Fish studies

Trawling for fish was carried out in April, May and June 2004 during a total of 28 days.

A.8.2.3. Bird studies.

The following bird surveys were conducted:

- Aerial surveys of birds in an 840 km^2 area 16 times during the period April 2000 - March 2004.
- Ship surveys of birds in a 500 km^2 area 35 times during the period April 2000 - March 2004.
- Radar and visual studies of bird migration . Observations were carried out 65 days during the period April 2002-March 2003 and 58 days during the period April 2003-March 2004

8.2.4. Marine mammal studies.

The following surveys of seals and porpoises were conducted:

- Aerial surveys in a 560 km^2 area 21 times during the period April 2002 and - March 2004. (conducted together with the bird surveys)
- Ship surveys in a 500 km^2 area 35 times during the period April 2000 - March 2004 (conducted together with the bird survey
- Acoustic monitoring of harbour porpoise from an anchored ship using T-PODs 2-3 days 15 times resulting in 36 days of observations .

A.8.3. Biological monitoring

The EIA report was finalised in 2004. The construction of the farm is planned to start 2012/2013, monitoring has therefore not been initiated

A.8.4. Cost estimate

A cost estimate of these activities is given in the table below.

	Cost €
Benthic fauna studies	180,000
Fish studies	180,000
Bird studies	660,000
Marine mammal studies	530,000
Total	1,550,000

A.9 GERMANY GENERAL GUIDELINES

A.9.1 Background

Bundesamt für Seeschiffahrt und Hydrographie in Germany has prepared general guidelines for investigations that are mandatory for baseline surveys and monitoring of impacts of offshore windmills in German waters. This section outlines the mandatory biological investigations.

A.9.2 Baseline Survey

In Germany the following baseline investigations for the Environmental Impact Assessment of Offshore wind farms are mandatory:

- Benthic fauna and benthic vegetation investigations

› Fish investigations

› Bird investigations and

› Marine mammal investigations

The investigations must cover two successive complete seasonal cycles

A.9.2.1. Benthic fauna and vegetation

The benthos, sediment and water quality investigations must comprise:

› Grab sampling survey of infauna during at least two consecutive complete seasonal cycles (spring and autumn) prior to the start of construction, i.e. at least four survey rounds. At least 20 stations in small areas (< 20 square nautical miles). At least two samples must be collected per stations. The samples shall be collected by 0.1 m^2 Van Veen grab

› Beam trawl/dredge survey of epifauna during at least two consecutive complete seasonal cycles (spring and autumn) prior to the start of construction, i.e. at least four survey rounds. The number of sampling sites depends on the number of infauna stations. Half of the infauna stations have to be surveyed by means of beam trawls or dredge hauls. In smaller areas (< 20 square nautical miles), ay least 10 beam trawl surveys or dredge hauls should be conducted

› Videosurvey of epifauna, near stations for beam trawl, dredge and grab sampling stations videosurvey of about 15-30 min duration and or photo with 10 to 20 photos per station

› Investigation of benthic vegetation (macroalgae/seagrasses) if present in the area, by videosurvey along transects. At least 3 transects in each habitat type must be carried out. once a year during two years prior to the start of construction

A.9.2.2. Fish

Fish survey by beam trawl or otter trawl must be carroed out twice a year (spring and autumn) at least two consecutive years before the start of construction. In project and reference areas > 100 km^2., the minimum number of hauls should be 30 each. 20 hauls will be sufficient if a beam trawl Is used. In project and reference areas < 100 km^2 the minimum number of hauls should be 20 each. 15 if beam trawl is used.

A.9.2.3. Birds

The bird investigations shall include:

› Monthly ship based transect counts of birds at least two consecutive complete annual cycles before the start of construction.

- Monthly aerial counts at least two consecutive complete annual cycles before the start of construction.

- Radar surveys of bird migration during main migration period (i.e. March to May and mid-July to mid November (end of November in the Baltic) at least two consecutive complete annual cycled before the start of construction. Survey frequency in the main migration periods must be 7 days/month.

A.9.2.4. Marine mammals:

The marine mammal investigations shall include:

- Aerial counts of marine mammals. The assessment area including the reference area must cover at least 2000 $km^2$and should have a rectangular shape

- Ship based counts of marine mammals. The assessment area of a project area must cover at least 200 km^2 in principle. The size of the reference area correspond to the size of the assessment area for the project

- Acoustic monitoring of harbour porpoise using 3 click detectors T-PODs at least two consecutive complete seasonal cycles prior to the start of construction

A.9.3. Biological monitoring

A.9.3.1. Benthic fauna and vegetation

Monitoring of impacts on benthic fauna and vegetation shall include:

- Monitoring of infauna by grab sampling during construction and operation phase. At least 20 stations must be sampled in small areas (< 20 square nautical miles). At least two samples must be collected per stations. The samples shall be collected by 0.1 m^2 Van Veen grab. In addition installation based effect monitoring has to be started upon completion of two installations during construction phase (with six sampling sites per installation). During the operation phase installation based effects monitoring must be carried out additionally at two wind turbines as a minimum (with six sampling sites per installation)

- Beam trawl/dredge s monitoring of epifauna throughout the construction phase and at least three years up to five years during the operation phase. Each year one survey shall be conducted during spring and one during autumn. The number of sampling sites depends on the number of infauna stations. Half of the infauna stations have to be surveyed by means of beam trawls or dredge hauls. In smaller areas (< 20 square nautical miles), ay least 10 beam trawl surveys or dredge hauls should be conducted

- Videosurvey of epifauna during construction and operation phase, near stations for beam trawl, dredge and grab sampling stations videosurvey of about 15-30 min duration and or photo with 10 to 20 photos per station

› Investigation of fouling on underwater structures. During construction and operation phases piles, foundations and scour protections must be surveyed by SCUBA divers that takes photo and videos and collect quantitative scratch samples at three depths. The survey shall be carried out after erection of piles/foundations and at least three years up to five years in the operation phase.

› Monitoring of benthic vegetation (macroalgae/seagrasses) if present in the area, by videosurvey along transects. At least 3 transects in each habitat type. Must be carried out once a year throughout the construction phase and at least three years up to five years if required after commissioning.

A.9.3.2. Fish

Monitoring of impacts on fish shall include:

› Fish survey by beam trawl or otter trawl once a year, one year during the construction phase and in the first, third and fifth year of the operation phase. In project and reference areas > 100 km^2, the minimum number of hauls should be 30 each. 20 hauls will be sufficient if a beam trawl Is used. In project and reference areas < 100 km^2 the minimum number of hauls should be 20 each. 15 if beam trawl is used.

› Additional Installation based fish monitoring at two operational wind turbines or set net

A.9.3.3. Birds

Monitoring of impacts on birds shall include:

› Monthly ship based transect counts of birds throughout the construction phase and at least three years, up to five years if required, after commissioning.

› Monthly aerial counts throughout the construction phase and at least three years, up to five years if required, after commissioning.

› Radar surveys and visual observations/recording of flight calls of bird migration during main migration period (i.e. March to May and mid-July to mid November (end of November in the Baltic) throughout the construction phase and at least three years, up to five years if required after commissioning. Survey frequency in the main migration periods must be 7 days/month.

A.9.3.4. Marine mammals

Monitoring of impacts on marine mammals shall include:

› Monthly ship based transect counts of marine mammals together with the bird count throughout the construction phase and at least three years, up to five years if required, after commissioning.

- Monthly aerial counts of marine mammals together with the bird survey throughout the construction phase and at least three years, up to five years if required, after commissioning. six additional aerial surveys per year covering only marine mammals have to be made

- Acoustic monitoring of harbour porpoise using 3 click detectors T-PODs throughout the construction phase and at least three years, up to five years if required after commissioning

- Surveys of waterborne noise emissions and immissions throughout the construction phase and within 12 months after the wind farm has been put into operation.

A.9.4 Cost estimate

A cost estimate of these activities is given in the table below.

General cost estimates for a 200 MW wind farm was received from two German operators, cf. tables below

	Cost planning phase €	**Cost construction phase €**	**Cost operation phase €**
Benthic fauna	1,200,000	600,000	1,200,000
Fish	210,00	105,000	210,000
Birds	2,250,000	750,000	2,250,000
Marine mammals	630,00	300,000	600,000
Total	4,290,000	1,755,000	4,260,000

	Cost planning phase €	**Cost construction phase €**	**Cost operation phase €**
Benthic fauna	425,000	210,000	425,000
Fish	75,000	40,000	75,000
Birds	500,000	250,000	500,000
Marine mammals	500,000	250,00	250,000
Total	1,500,000	750,000	1,250,000