KnowSeas

Knowledge-based Sustainable Management for Europe's Seas

Deliverable 4.3 Assessment of Future Benefits

Authors:
P. Cooper, A. Hunt, L. Anneboina, B. Hutniczak, A. Munch, I. Goulding,
L. Onofri, P. Nunes, T. Luisetti, K. Turner and E. Jackson

May 2012

The research leading to these results has received funding from the European Community's Seventh Framework Programme [FP7/2007-2013] under grant agreement number 226675

CONTENTS

Index to Documentation

Title	Author(s)	Documents
Introduction and overview	P. Cooper (UoB)	This document: D4.3 Introduction and overview
Projected value of energy from marine sources in Europe	P. Cooper, A. Hunt & L. Anneboina (UoB)	D4.3 Energy.doc D4.3 Energy.xls
Economic valuation of European commercial fisheries under good environmental status	B. Hutniczak & A. Munch (SDU) I. Goulding (MegaPesca)	D4.3 Fisheries.doc D4.3 Fisheries.xls
Projected value of freight transport in Europe's seas	P. Cooper, A. Hunt & L. Anneboina (UoB)	D4.3 Freight.doc D4.3 Freight.xls
A short note on the future benefits of tourism, its drivers and consequences for marine ecosystems in Europe and Northern Africa	L. Onofri & P. Nunes (formerly UNIVE)	D4.3 Tourism.doc
Water quality, recreation and carbon storage possibilities in European coastal and marine areas: trends and future perspectives	T. Luisetti & K. Turner (UEA), E. Jackson (UoP-MI) re *P. oceanica*	D4.3 Water quality & carbon storage.doc

Note for the printed version
The printed version of Deliverable 4.3 includes only the above Word documents (suffix .doc). The datasets and computations in the above Excel spreadsheets (suffix .xls) are available to download from the KnowSeas website at: http://www.knowseas.com/partners-area/completed-deliverables.

KnowSeas D4.3

Introduction and Overview

P. Cooper, University of Bath

Following the format of Deliverable 4.2, this deliverable comprises a series of analytical papers and datasets, each of which deals with a particular form of benefit derived from marine ecosystems. This paper provides an introduction to those components, in terms of the objectives of the deliverable and general methodological guidelines, and an overview of the results. It is emphasised that the component analytical papers have been independently prepared by the designated authors (see the index above for a summary) and the views expressed by individual authors are not necessarily shared by other members of the work package. Concluding remarks in this paper deal with possible future developments which represent a paradigm shift in existing forms of benefit or new uses for Europe's seas.

1. Objectives and Scope

Deliverable 4.2 dealt with the calculation of estimates at the aggregate, i.e. EU, level of annual benefits (and thus potential costs) associated with the exploitation of Member State Exclusive Economic Zones. This involved a scoping process to identify the principal benefits and estimation in these cases was built on the latest available annual data at the time (generally, that for 2009). As such, this previous deliverable provided a 'snapshot' of the main benefits for a single year based on historical data. The objective of this Deliverable 4.3 is to extend this perspective, estimating the *future* benefits that might be expected from the continued exploitation of Europe's seas. Thus, its aim is to enhance the scope of economic analysis envisaged in the Marine Strategy Framework Directive (MSFD) for economic analysis of "the use" of marine waters – future prospects provide a more useful basis for planning decisions than does the historical position, which may not reflect developments relevant to such decisions.

In terms of the KnowSeas project, the intention of the work encompassed by this deliverable is to inform the economic element of the KnowSeas case studies concerned with particular seas and, more generally, to demonstrate the application of economic principles as envisaged in the Directive, as was the case for the previous deliverable. Similarly, the work is predicated on the use of *available* data relevant to assessing future developments so that the secondary objective of this research is to identify shortfalls in such data that compromise the economic assessment of future developments.

The scope of the work in terms of the benefits and countries covered continues that of Deliverable 4.2 – details are provided in the "Introduction and Overview" paper of D4.2. However, it is emphasised that the scope is not restricted to EU Member States where other countries contribute significantly to the exploitation of Europe's seas. For example, the analysis of energy-related activity in the North Sea area of the Northeast Atlantic would be incomplete without recognition of the role of Norway. Nevertheless, the presentation of results distinguishes between the EU27 and other countries, as well as highlighting results by European sea.

It is also emphasised that benefits were selected which were likely to be relatively substantial in terms of their monetary value and representing different qualitative dimensions in order to enrich the range of valuation techniques demonstrated in the course of the study. As shown in Table 1, these dimensions were:

- "Source of value": A distinction is drawn in terms of whether the level of benefit derives from currently functioning ecosystem services or simply from exploitation of the "marine space", the water-body and the resources lying beneath it. For example, fisheries depend on a well-functioning ecosystem while the amount of maritime freight transported or the amount of hydrocarbons extracted from the seabed do not.

- "Type of value - valuation base": Type of value refers to the categorisation discussed in D4.1 with the emphasis on use values given the paucity of data on existence and bequest values in the marine context (further discussed in the concluding section). Valuation base refers to the method by which values may be determined, broadly by observation of values revealed by markets versus those derived from stated preferences.

Application of these criteria resulted in the selection of the cases summarised in Table 1.

Table 1. Cases selected for analysis

Type of value -Valuation base	Source of value: Ecosystem services	Source of value: Marine space
Direct use		
- market value	Fisheries	Energy
	Recreation (visits)	Freight transport
- WTP	Recreation (water quality)	
Indirect use		
- cost avoidance	Carbon storage	

2. Methodological Approach

The methods employed in the analysis of each of the selected cases are detailed in the respective analytical papers. These methods were selected by the respective authors in accordance with the agreed guideline of seeking to establish present (i.e. discounted) values of benefits over the time horizon to 2030 or beyond.[1] Thus, there is less standardisation of methods than in Deliverable 4.2, reflecting variation in the availability and the nature of forecast data. For example,

i. creditable forecasts of energy extraction (BP, 2012) employed in the paper on energy extend to 2030 whereas assumptions about the loss of ecosystem capacity for carbon storage can be made up to 2050, and
ii. estimates of future catch in the fisheries sector depend on policy decisions, so that alternative scenarios are available.

In common with Deliverable 4.2, given that computational procedures would vary depending on the source data, no standard procedure was prescribed. Rather, it was agreed that relevant data, its sources, as well as assumptions and calculations would be recorded in Excel spreadsheets - these are included in the deliverable, where available.

Also in common with the previous deliverable, since the study had to be based on existing secondary data, it was left to the individual researchers to determine the most appropriate sources of data for the cases with which they were respectively concerned. Furthermore, it was

[1] This horizon was informed by discussions at the Third Scientific Workshop which indicated that the 2020 horizon envisaged in the MSFD would be too short-term as a basis for making truly long-term planning decisions.

recognised even where there is good availability of market data there would remain choices and limitations as to the form of economic value that could be extracted therefrom. Ideally, some measure of consumer surplus would be obtained but this would require models of how activity in one sector diffuses through the economic system and the nature of the demand schedule for individual goods and services resulting in final consumption. Pugh (2008) instead uses gross value added, which at least recognises the contribution from an economic sector to other processes, but this relies on input-output tables for the UK, the subject of his study. To simplify matters for this aggregate cross-country study, we decided to use sectoral revenues. Their calculation is relatively straightforward and they represent value to the economy in the sense that as market prices they represent the willingness-to-pay of intermediate producers and ultimately consumers.

Despite the research effort represented by the deliverable's analytic papers, users need to bear in mind the caveats attached to the resultant values deriving from data/forecast availability as well as necessary assumptions in their calculation. While there can be no pretence to absolute precision, the values provide at least some sense of the magnitudes of values which are likely to be derived from Europe's seas.

3. Overview of Component Papers

This section provides a brief overview of the papers in this deliverable organised according to the type of benefit derived from marine ecosystems, commencing with forms of use value then indirect use value.

Energy (D4.3 Energy.doc)
The benefit of this sector in terms of current revenues in Deliverable 4.2 (Cooper, 2011)[2] was found to substantially dominate other sources of value, with the Northeast Atlantic (NEA, especially the North Sea) as essentially the sole contributor. Based on available forecasts, these phenomena look set to continue at least over the 20 year time horizon employed in this study.

Despite rapid expected growth in the deployment of renewable technologies, the hydrocarbon element in the marine energy mix remains by far and away the most important both in terms of the calorific value of the energy produced and monetary value (based on revenues). Furthermore, based on National Renewable Energy Plans, it is the Member States bordering the NEA which are looking to develop marine renewables the most extensively and rapidly, reflecting the relative abundance of energy for extraction from winds, tides and waves.

Freight (D4.3 Freight.doc)
Although publicly available forecasts of maritime freight traffic could not be identified, empirical analysis of its historic relationship with GDP found a very strong positive association which was applied to available long-term forecasts of GDP to impute a forecast of traffic. Long-term forecasts of GDP may be argued to be unreliable in the current economic climate and, indeed, it was demonstrated in the previous deliverable (Cooper, 2011) that recent years had witnessed a global downturn in GDP at odds with historic trends. However, as argued in that deliverable, a recovery of the economy is likely to occur and current long-term forecasts of GDP may be seen as representing trends which will be resumed – the issue of course is how long will be the hiatus before these trends are resumed.

[2] Cooper, P. (2011) KnowSeas Deliverable 4.2 Energy Sector

This issue goes beyond the scope of the current work and is addressed by using the latest available forecasts, which will take some account of current conditions.

Recreation and tourism (D4.3 Tourism.doc & D4.3 Water quality & carbon storage.doc)
The paper by Onofri and Nunes reinforces the finding in the previous deliverable that activity in the tourism sector in the EU and North Africa is influenced by the quality of marine ecosystems, as reflected in measures of protected coastal areas and beach length.[3] As such, future tourism activity in Europe's seas is likely to be dependent on the preservation or improvement of such ecosystems. This motive is seen in the paper by Luisetti et al. as underlying the increasing levels of bathing water quality reflected in the trend in growth of beaches awarded Blue Flag status which they document.

Fisheries (D4.3 Fisheries.doc)
In their paper, Hutniczak et al. assess the economic impact of achieving Good Environmental Status in the EU's commercial capture fisheries, being one of the descriptors listed under the MSFD, in terms of landed value using 2010 prices. The approach adopted is to evaluate landings under different environmental scenarios and use the differences between them to highlight the economic impacts of each. They find that among their scenarios the one involving cessation of exploitation to allow stock recovery and reopening with mortality limited to the maximum sustainable yield produces the highest present value for the period 2010-2035, with the largest gains over other scenarios in the Arctic area and Wider Atlantic. They recognise that such a scenario may be unrealistic in practice as it involves closure of certain fisheries over extended periods but the scenario provides a benchmark against which other policies can be assessed.

Carbon storage (D4.3 Water quality & carbon storage.doc)
The potential loss of indirect use value associated with diminution of marine ecosystem components that sequester carbon are dealt with in the paper by Luisetti et al.

Based on the limited available data for relatively recent periods, it is shown that the main threat to saltmarsh area lies in the Mediterranean. Consequently, in the absence of forecast losses, conservative scenarios are used to evaluate the impact of future saltmarsh losses. Even the more pessimistic of these is shown to result in relatively small losses of value when compared to the benefits derived from direct use values, see above.

Potential seagrass loss is shown by Luisetti et al. to be more significant than saltmarsh loss in terms of carbon storage capacity and in terms of risk of loss – there exist credible predictions of substantial loss amounting to 80% or more of the current stock. Thus, pessimistic scenarios produce loss values more than an order of magnitude greater than those envisaged for saltmarshes. Nevertheless, the absolute values are still relatively small compared to direct use values covered above.

Taken together, these studies evidence the continuing economic importance of Europe's seas in the future based on current activities, even given the limitations in attempting to attach precise values based on uncertain forecasts and with arguable bases for valuation; the next section considers how future change may affect these activities and introduce new ones. Before considering these, it is worth noting that the economic values attaching to exploitation of the marine space (in the energy and freight transport sectors) remain dominant over those attaching to

[3] The potentially growing importance of tourism up to 2030 in north African and other southern Mediterranean countries has recently emphasised by Lanquar, R. (2011) Tourism in the Mediterranean: Scenarios up to 2030, MEDPRO Report No. 1, July.

the use of functioning ecosystem services (tourism, fisheries etc.) but this is not to say that further exploitation of the marine space justifies loss of ecosystem services. Decisions where there is a conflict between the two should be informed by a specific analysis of how a proposed change affects the value of benefits derived from ecosystem services.

4. Concluding remarks – Paradigm Changes and Emerging Sources of Value in Europe's Seas

The papers included in this deliverable deal with projection into the future of current activities. In this section, attention is directed towards how these activities may be radically transformed (paradigm changes) and what new activities may arise over the next 20-30 years.

First, what paradigm changes might affect existing activities?

Energy

Looking beyond the 20 year horizon at longer term trends, the exhaustion of the currently exploited reserves of hydrocarbons in the NEA will inevitably mean that renewable sources of energy increase as a proportion of the marine energy mix, but it remains to be seen whether new, economically viable reserves will prolong hydrocarbon production and whether the cost of marine renewable electricity generation will constrain growth in the proportion of energy derived from renewable sources.

Currently, costs of development and operation are such that financial incentives are required for the development offshore renewable energy, for example in the UK through the Renewables Obligation Certificate scheme and in the future through the proposed Contract for Difference arrangement which will secure income streams for producers sources. However, technological development and economies of scale may well operate so as to reduce the costs of renewable energy in the future.

Freight

While the volume of goods may be associated with general economic activity, the routes over which cargoes are carried may change. Particularly notable in this context is that climate change, leading to the retreat of arctic ice cover, may make new routes viable such that more traffic between Asia and Europe will pass through the Arctic Ocean north of Canada (the Northern Sea Route, NSR) rather than through the Mediterranean via the Suez Canal. Schoyen and Brathen (2011)[4] report that the NSR is 40% shorter and its use could double vessels' operational efficiency. Therefore, if this route becomes viable, it is likely that shipping pressures associated with Asian trade could significantly switch from the Mediterranean to the NEA.

Tourism

The paper by Luisetti et al. in this package notes the importance of Mediterranean tourism and the potential for increased summer temperatures due to climate change that might impair such tourism activity. It is also notable that climate change may also reduce the availability of freshwater, which would also constrain tourism. In the current context, the question is whether these changes might shift tourism to other European seas, producing a different distribution of economic benefits within the Union, or to external destinations.

[4] Schoyen, H. and Brathen, S. (2011) The Northern Sea Route versus the Suez Canal: cases from bulk shipping, *Journal of Transport Geography*, 19, 977-983.

Second, what are the prospective benefits that might be derived from activities that are not currently undertaken or are relatively insubstantial?

Carbon sequestration
Both the marine space and its ecosystem services have been suggested as venues for the sequestration of carbon. In the former case, erstwhile sub-benthic hydrocarbon reservoirs constitute a repository for liquefied carbon species as do deep sea injections. In the latter case, geo-engineering solutions to climate change have included the encouragement of phytoplankton blooms with iron fertilisation, thus sequestering carbon in biomass.

Exploitation of biota
Expanding the European dietary range to include species not widely enjoyed currently, e.g. seaweeds, is a possible development that will affect marine systems. Should this occur there is likely to be an increased pressure for the implementation of maricultural technology. A more uncertain, but potentially more significant, development lies in the exploitation of the gene pool of marine species to meet human needs such as the use of starfish to produce anti-inflammatory drugs. In both cases, there is an underlying need to preserve or enhance marine ecosystem integrity and biodiversity.

Mineral extraction
Society's hunger for minerals and the diminution of terrestrial sources is likely to inspire the continued search for extractable reserves of such minerals in the marine environment.

Water
As noted above in the context of tourism, climate change may lead to excess demand for freshwater in parts of the Union. Consequently, while currently uneconomical, desalination may become necessary to meet European demands, particularly in the absence of a 'water grid' connecting areas of excess supply with those of excess demand.

To avoid carbon emissions, nuclear energy may become more favoured. Should this occur, discharges of radioactivity will need to be monitored and controlled to minimise harm to ecosystems.

Use of physical structures
The creation of offshore structures, especially in support of energy generation, will precipitate opportunities for the development of benefits as by-products. The physical obstacle presented by such structures is likely to impede other uses, thus creating marine conservation zones, while the structures themselves may constitute a substrate for the growth of shellfish species readily available for harvest.

It remains to be seen to what extent these possibilities become realities, there is no reliable basis for predicting which, if any, of them will be realised. Nevertheless, the potentially large impacts they entail mean that the possibilities themselves constitute issues of which marine planners and policymakers will need to be aware.

KnowSeas D4.3

Projected Value of Energy from Marine Sources in Europe

P. Cooper, A. Hunt and L. Anneboina
University of Bath

1. Introduction

The aim of this paper is to assess the future benefits from the energy sector in terms of the market values of energy derived from use of the marine environment in Europe. This builds on the analysis of current benefits as reported in Deliverable 4.2 (Cooper, 2011), and includes both hydrocarbons (oil and gas) as well as renewable sources (predominantly wind energy).

The overall method comprises two stages:
a) quantification of forecast physical production in EU countries, and
b) valuation of this output using a monetary metric, i.e. price per unit of energy production, aggregated over the relevant time period in terms of present (discounted) value.

In line with the guideline for this deliverable, we consider the period 2010-2030, which covers the period for which there currently exist production projections, at least in respect of hydrocarbons. It should be noted that whilst projections are presented at 5-year intervals over this time period, calculations that underlie the final monetary values require the use of annual estimates, which we derive by linear interpolation between the 5-year projections. To reflect our overall methodological approach, the next section of the paper provides data on projected energy production from different sources. The subsequent section of the paper then deals with monetary valuation and the final section with aggregation of annual values as present values.

2. Marine-based Energy: Future Physical Projections for Europe

2.1 Data: Hydrocarbons

Whilst there are a number of estimates of future energy *use* at a national level (e.g. IEA, 2011) and the IPCC work on emission scenarios (Nakicenovic, 2000), *production* data are not as readily accessible. The most comprehensive analysis relating to global projections of hydrocarbon production that we identified as covering the time horizon of interest was the BP Energy Outlook 2030 (BP, 2012). The data presented here is based on our interpretation of the trends outlined in this source.

In order to apportion this aggregate total between countries, and in the absence of any information to apportion otherwise, we assumed that the current (2010) percentage share of oil/natural gas production of each country to total current oil/gas production for the Europe and Eurasia region is maintained over the period to 2030. Thus, it is assumed that the future national distribution of hydrocarbon production is the same as the current split.

As in D4.2, scope is restricted to the five major current producers of hydrocarbons in Europe (Denmark, Germany, Netherlands, United Kingdom and Norway) which currently account for approximately 80-90% of total European production (Cooper, 2011). As it was found in D4.2 that the vast bulk of hydrocarbon production in these countries is offshore, their future production is treated as exclusively from this source.

Data on current oil/natural gas production comes from BP (2011) and IEA (2011). Where current energy production data for a particular country was not available from the BP dataset (e.g. current oil production data for Germany and Netherlands), the breakdown for these countries was based on IEA (2011), as used in KnowSeas D4.2. The small discrepancies between the BP and IEA data for 2010 for Denmark, UK and Norway led us to believe that there may be a systematic difference in the ways in which the two organisations generated their estimates. Consequentially, in order to retain consistency with the BP data, we scaled the IEA data for Germany and Netherlands according to the percentage discrepancy identified for the other countries (see the workings in KnowSeas D4.2 Energy Sector, Cooper, 2011).

At a generic level, the BP data projections make the following key assumptions (details are given in BP, 2012):

1. Energy efficiency will improve significantly, particularly in OECD countries, and that governments around the world will adopt regulations to limit greenhouse gas emissions.

2. Global economic growth continues at current levels, leading to primary energy growth of 1.7 per cent per year, equivalent to nearly 40 per cent over the next 20 years, with the majority of that growth coming from non-OECD countries.

3. BP expects that natural gas use will grow faster than coal and oil, which it suggests will reach peak demand in 2005 in OECD countries. Higher efficiency in transportation will contribute to slow growth of oil use, while BP expects that biofuels will represent 6 percent of liquid fuels in 2030.

2.2 Physical Production Projections: Hydrocarbons

The central projections of hydrocarbon production to 2030 by the EU27 countries within scope are presented in Figure 1. This figure shows that total hydrocarbon production is estimated to increase at a steady pace up to 2030, equivalent to roughly 1.5% per annum growth over the 20-year period, reflecting the assumptions noted above. However, it is notable that this growth is attributable to projected increases in natural gas production, with oil production gradually declining – see also Annexes A1 and A2.

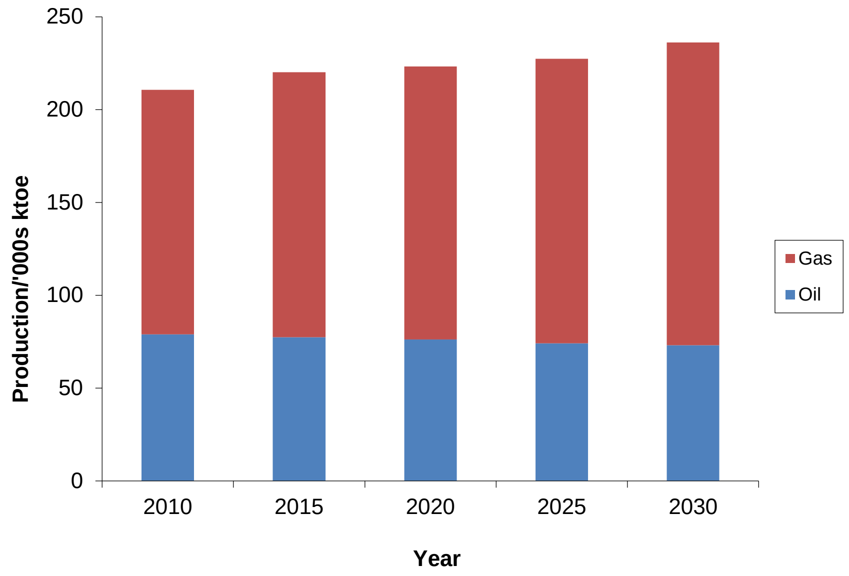

Figure 1. Forecast hydrocarbon production in top four producing EU27 countries
Note: Based on BP (2012)

Figure 2 shows projected total crude oil production by the EU27 countries and Norway, which is included as the other major producer in Europe. The dominance of Norway – which currently produces more annually than all EU27 countries combined - is projected to be maintained in future years to 2030. The projections show a decline to 2030 from current production levels. The BP report argues that this trend is likely to result from technical efficiencies in the use of oil in transport that imply a reduction in demand, and therefore production.

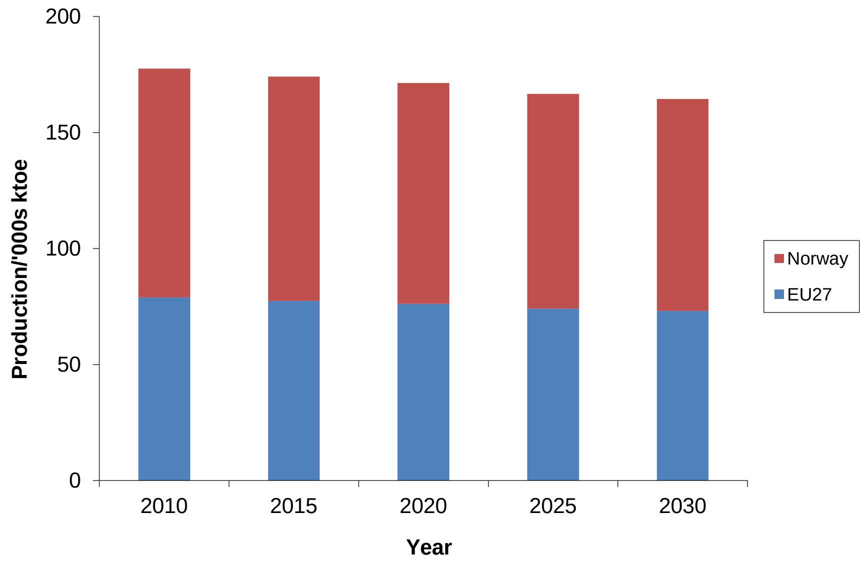

Figure 2. Forecast crude oil production in top four producing EU27 countries + Norway
Source: Based on BP (2012). Country-level projections in Annex A1.

According to BP (2011), at the end of 2010 the proven oil reserves of the EU stood at 6.3 billion barrels and those of Norway at 6.7 billion barrels, implying reserves-to-production (R/P) ratios of 8.8 and 8.5 respectively. Thus, in both cases continued production at those levels would exhaust (proven) reserves before 2020. This outcome is reflected in a conservative scenario in the monetary results presented below: the "proven reserves scenario". An alternative scenario, the "continued production scenario", involves a longer period to depletion based on additional potentially recoverable reserves reported by the IEA (2011), see Figure 3. On this basis, potentially recoverable "conventional oil" is equivalent to about double the amount projected to be produced by 2035.

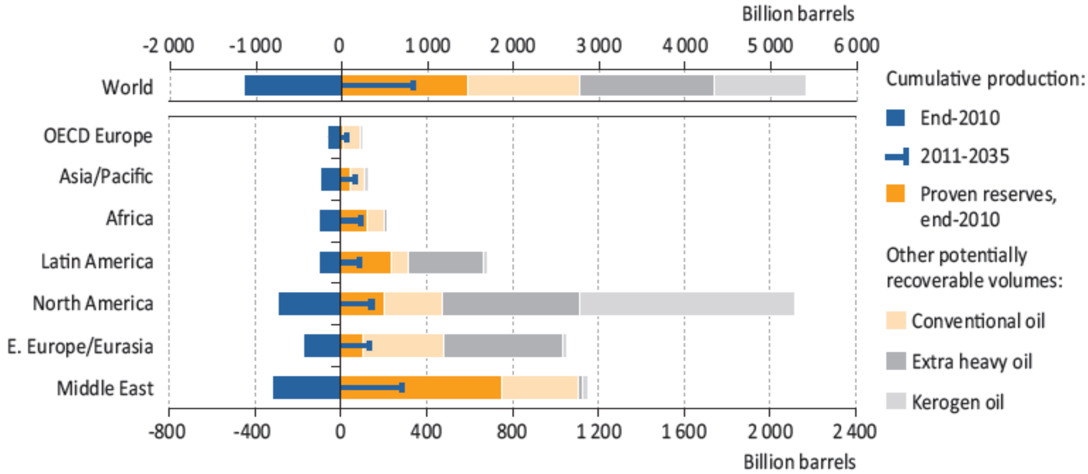

Figure 3. Recoverable oil resources and production by region and type at end-2010
Note: Cumulative production to date is shown as a negative number, whilst the total of the bars to the right indicate remaining recoverable resources.
Source: IEA (2011) "New Policies" scenario.

Turning to natural gas production, Figure 4 presents projections to 2030 for the countries within scope and indicates expected increases in the level of production. As in the case of projected oil production, Norway is likely to continue to be a significant producer of natural gas in Europe.

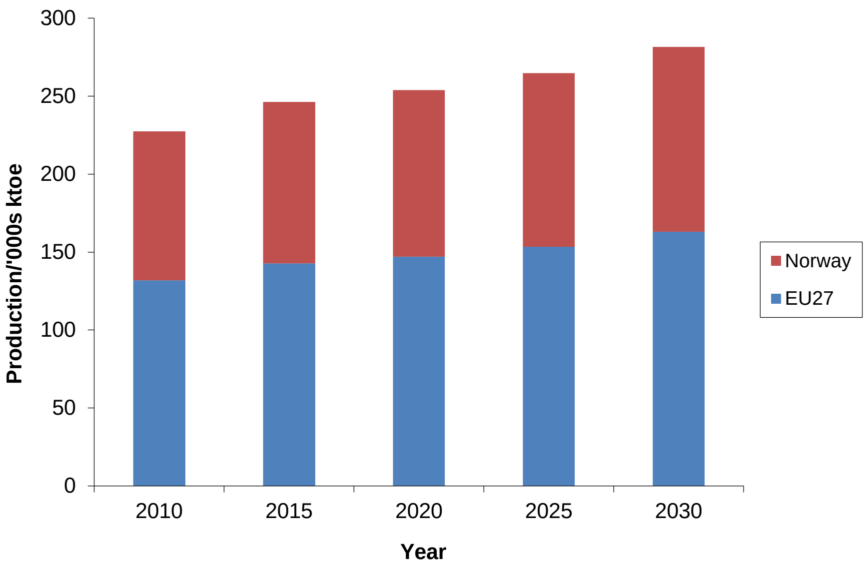

Figure 4. Forecast natural gas production in top four producing EU27 countries + Norway
Note: Based on BP (2012). Country-level projections in Annex A2.

As in the case of crude oil, the ratios of proven natural gas reserves to annual production at the end of 2010 indicate that reserves will be depleted before the end of the 2030/35 time horizon employed here - the ratios per BP (2011) were 8.5 for the EU27 countries and 19.2 for Norway.

Again, the more conservative position, based exclusively on proven reserves, is reflected in the "proven reserves scenario" while the "continued production" scenario also recognises potentially recoverable amounts per IEA (2011) - see Figure 5. The graph line for OECD Europe shows that such conventional natural gas is equivalent to about three times the proven reserves.

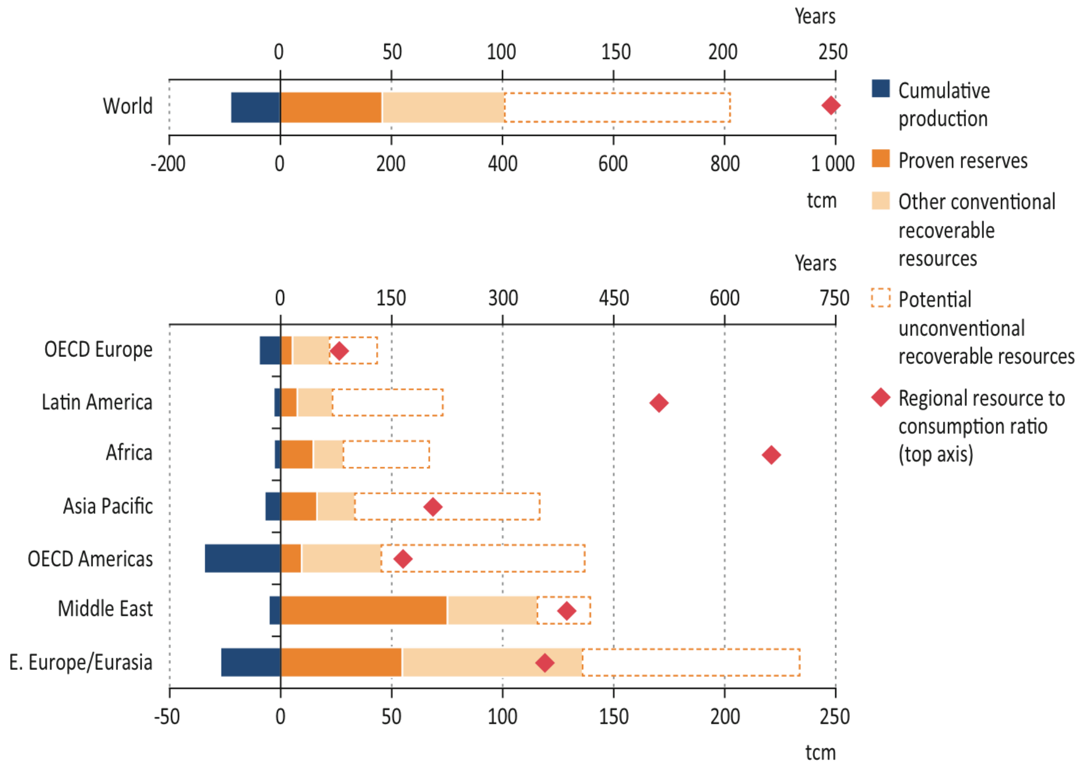

Figure 5. Recoverable gas resources and production by region and type at end-2010

Note: Cumulative production to date is shown as a negative number, so that the total of the bars to the right indicates remaining recoverable resources. tcm = trillion cubic metres.
Source: IEA (2011).

2.3 Uncertainties in Hydrocarbon projections

It is important to highlight that future energy projections are susceptible to a number of sources of uncertainty. They include economic growth affecting demand and technological development that affects both the economics of hydrocarbon extraction and the development of potential substitutes. These are – in turn – influenced by national and international governance, including energy and climate policies.

As outlined above, the projections presented – based on BP data – incorporate a single set of assumptions relating to economic growth, energy efficiency, etc. The uncertainties inherent in projecting those variables are therefore not represented. However, in the absence of alternative sets of projections regarding hydrocarbon production in Europe it is possible to use data ranges on energy demand as a first order proxy to give a sense of the likely scale of uncertainty entailed in energy production projections.

We therefore take the data given in IEA (2011) for three scenarios that project primary energy demand for the OECD regional grouping of countries and identify the variation – in percentage terms – across the range of scenarios. The central scenario (the “New Policies” scenario[5]) is broadly similar to the BP scenario, and includes current, as well as newly announced policies. The Current Policies scenario only includes policies already implemented, whilst the 450 scenario assumes that policies will be introduced so that the greenhouse gas emission reductions required to achieve atmospheric concentration levels of CO_2 of 450 parts per million will be achieved by 2050. The latter two scenarios therefore provide “high” and “low” scenarios, respectively, around a central scenario broadly equivalent to the BP scenario that underlies their production projections.

Table 1 shows the deviation, in percentage terms, in energy demand in OECD Europe across two projections, relative to the central projection. Thus, for example, demand for oil is in a range from 8% above the central scenario to 16% below the central scenario in 2030, depending on what policy path scenario is assumed. Whilst energy demand in OECD Europe differs from production as a result of the balance of exports and imports of oil and gas from the region, one might expect there to be some relationship between the two; at minimum, the range of uncertainty may be expected to be broadly comparable.

Table 1. Sensitivity of energy demand to policy scenarios for OECD Europe (% change from central scenario)

	Current policies		450 ppm limit	
	2020	2030	2020	2030
Oil	3	8	-5	-16
Gas	0	3	-7	-21

The data relating to energy demand in Table 1 is presented in order to provide the reader with a sense of a plausible range of uncertainty that might be attached to the BP production scenario. The physical production in Figures 2 and 4 above and the aggregate monetary data relating to hydrocarbons in Table 4 below could be adjusted by the percentages given in Table 1 to give ranges that represent these uncertainties.

A further uncertainty relates to the extent to which reserves are recoverable – as highlighted above. Whilst the central results assume that all potentially recoverable resources will be recovered (the “current production” scenario), we also present a more conservative scenario assuming that only currently proven reserves will be extracted (the “proven reserves” scenario).

2.4 Data: Renewable Energy

The principal data on future renewable energy production is taken from ECN (2011) which collates the renewable energy projections of the EU Member States as published in their respective National Renewable Energy Action Plans (as required by the Renewable Energy Directive). This source was found to be comprehensive in terms of data coverage over marine renewable energy sources and future time periods in Europe among all the data sources explored, and, moreover, represent official projections, developed in order to meet CO_2 emission reduction targets. However, these plans extend only up to 2020 and in our uncertainty assessment we also make use of alternative data projections from the IEA and the European Wind Energy

[5] Selected key policy assumptions for the EU under the New Policies Scenario are an Emissions Trading Scheme (ETS) covering power, industry and (from 2012) aviation; new Light Commercial Vehicle (LCV) standards; more stringent Passenger Light-Duty Vehicle (PLDV) standards. In the New Policies Scenario, the world is on a trajectory that results in a level of emissions consistent with a long-term average temperature increase of more than 3.5°C. Energy efficiency improves in the New Policies Scenario at a rate twice as high as that seen over the last two-and-a-half decades, stimulated by tighter standards across all sectors and a partial phase-out of subsidies to fossil fuels.

Association. The ECN-collated data are for future years – 2015 and 2020. We extend the data to 2025 and 2030 by assuming that the same percentage change between 2015 and 2020 pertains to the following two 5-year time periods.

2.5 Physical Production Projections: Renewable Energy

The planned production of marine-based renewable energy for EU27 countries per ECN (2011) is illustrated in **Error! Reference source not found.**. Planned onshore wind generation is included in this figure to provide a comparative base. The figure shows that electricity generation from marine renewables is planned to grow rapidly throughout the period to 2035, with wind energy comprising the vast majority of the total marine energy production. However, even with this rapid rate of growth in offshore wind generation, it still makes a smaller contribution to the marine energy mix than onshore wind in 2020 (28.45% versus 70.25% - see Table 2).

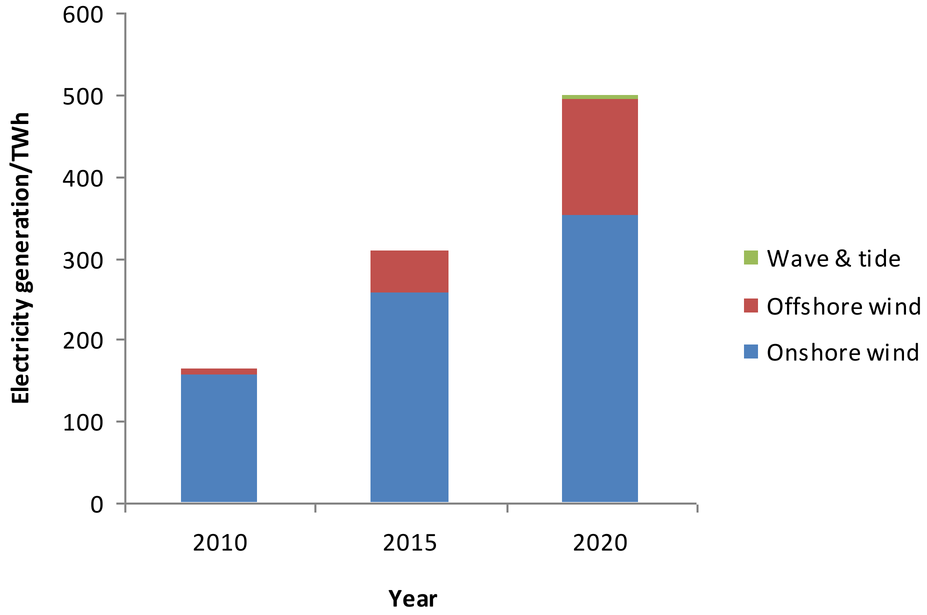

Figure 6. Forecast electricity generation by selected renewable methods in EU27
Source of data: ECN (2011)

Although onshore wind is projected to remain dominant at 2020, continuation of the rates of the relative rates of growth for each source in the period 2015-2020 per ECN (2011) would mean that by 2030 offshore wind energy would dominate the other sources (see Table 2) because of the substantial growth rates envisaged for marine renewables, outstripping that envisaged for onshore wind.

Table 2. Extrapolation of planned growth in selected renewables in EU27

	Per ECN (2011)				Extrapolation		
	2015	2020	Propn.	Implied growth rate 2015-2020	2025	2030	Propn.
Onshore wind	257.70	351.80	70.25%	36.51%	480.25	655.60	29.98%
Offshore wind	49.86	142.47	28.45%	185.75%	407.10	1163.32	53.19%
Wave & tide	0.87	6.51	1.30%	652.14%	48.93	368.05	16.83%
Total	308.42	500.77	100.00%	62.36%	936.29	2186.97	100.00%

As noted above, this extrapolation procedure is employed to extend the projections based on National Renewable Energy Plans for use here. Furthermore, the scope of the work is restricted to the major hydrocarbon producers identified above, with the exclusion of Norway and inclusion of France, since the latter is among the top four Member States in terms of planned offshore wind electricity generation in 2020 per ECN (2011) and Norway is under less pressure to develop marine renewables given its increasing production of hydrocarbons, see above. Adopting this country scope captures 83% of the planned offshore wind output in 2020 of some 142.5 TWh ((ECN, 2011). For the countries thus within scope, the production data utilised here are as shown in Figure 7, alongside the actual 2009 data per Cooper (2011), with energy expressed in terms of oil equivalents according to calorific value to support comparison with Figures 1, 2 and 4.[6]

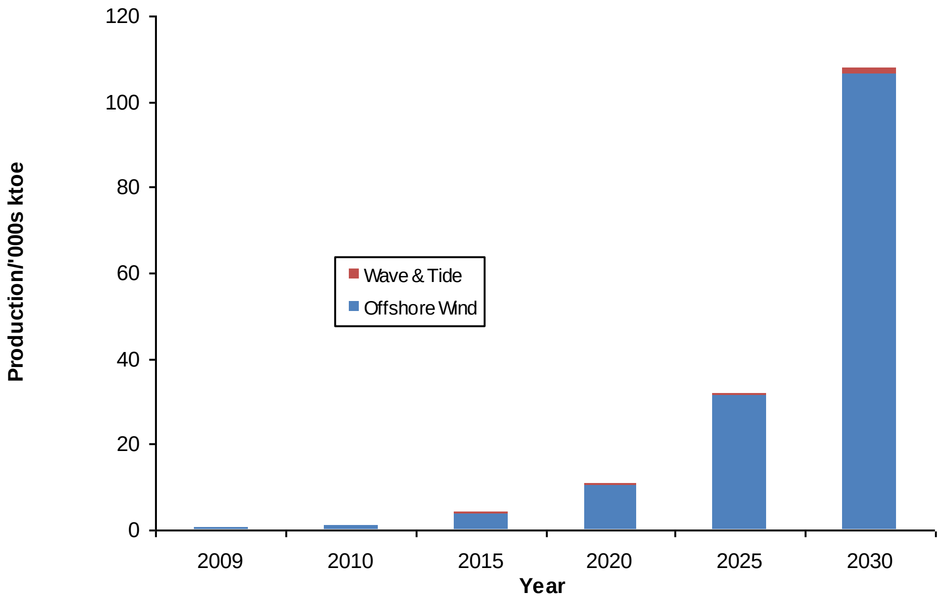

Figure 7. Forecast marine renewable energy production
Source of data: 2009: Cooper (2011); 2010, 2015, 2020: ECN (2011); 2025, 2030: Extrapolation using the country-level growth rate in planned production for 2015-2020 per ECN (2011)

2.6 Uncertainties in Marine-based Renewables projections

Marine-based renewable energy production in Europe is susceptible to a similar range of uncertainties as hydrocarbon production. Consequently, as with our treatment of hydrocarbons we make use of the alternative renewable energy scenario projections given in the IEA (2011) assessment. In this case, however, since the renewable energy is converted directly to electricity

[6] The conversion rate from TWh, the unit often used in electricity generation, is: 1 toe = 11,630 kWh (Source: DUKES, 2011: http://www.decc.gov.uk/assets/decc/11/stats/publications/dukes/2293-dukes-2011-annex-a.pdf), equivalent to 1 ktoe = 11.63GWh or 1000 ktoe = 11.63 TWh.

production utilised in the EU, there is no need to proxy supply through the use of demand projections. The IEA data on wind energy production data does not disaggregate by offshore and onshore production. Consequently, we adopt the same assumption as was made in the data treatment for hydrocarbons, i.e. of using the 2009 proportion of offshore production in total production for the main producers of offshore wind energy among the EU27 countries namely, Denmark, Germany and the UK, according to D4.2. Comparing the 2009 off-shore production of 7TWh (EWEA, 2009) with the total wind production in the EU for that year of 133WWh (IEA, 2011) we derive a figure of 5.4%. Thus, country-level attribution of production future periods is made on the basis of countries' contributions to current EU aggregate production. For consistency, adopting this same assumption for future wave and tide energy production implies that total future EU production is attributed to France.

An additional scenario is provided by the European Wind Energy Association projections (EWEA, 2011). This represents an industry target, based on what the EWEA judges to be realistic for offshore production, in the light of current and planned developments. The EWEA scenario projections are shown in Table 3, below. These can be directly compared to the offshore projections in the third column, made by assuming that offshore production remains at 5.4% of the IEA projections of total wind energy production in the EU. Conversely, the EWEA "Total" production projections are derived by assuming that the offshore projections are 5.4% of these totals. A comparison of the two Total columns in the table shows that on the basis of this assumption, EWEA projections are substantially higher than those made by the IEA under an aggressive GHG mitigation scenario.

However, if the assumption is relaxed to assume that offshore production comprises a growing proportion of total wind production in Europe, the two scenarios may be viewed as more consistent with each other. Thus, if offshore wind production is assumed to be 65% of total production by 2030, the scenarios would be entirely aligned. The relaxation of the assumption may be judged to be realistic given the growing resistance to onshore wind farms across Europe currently observed, combined with the development of technologies that allow for the more efficient transmission of energy from offshore wind farms.

Table 3: Wind energy scenarios for Europe (TWh)

	IEA (450)		EWEA	
	Total	Offshore	Total	Offshore
2020	495	28	2,370	128
2030	862	49	10,426	563

Annex A presents the hydrocarbon and renewable energy production forecast for the EU27 countries (broken down by the key producers) and Norway.

3. Methodology for Monetary Valuation

Price data for hydrocarbons is taken from IEA (2011). Prices in real terms (2010 prices) are taken from the 'New Policies Scenario' for the years 2010, 2015, 2020, 2025 and 2030, as summarised in Annexes B1 and 2. These represent price rises in future periods, reflecting a combination of increased global demand as well as greater relative scarcity.

The above prices are multiplied by quantities to derive the value of hydrocarbons for each year to 2030[7]. Aggregate total values, (€ million, 2010 prices), are then estimated on a discounted,

[7] Annual values of production were derived on the basis of linear interpolation across the intervening individual years in the 5-year periods given between the years 2010, 2015, 2020, 2025 and 2030.

present value, basis, using a 4% per annum discount rate as a central rate.[8] Alternative discount regimes of 2% and 6% are introduced in the sensitivity analysis, in accordance with EC DG Environment practice.

Future price projections for wind, wave and tide-generated electricity were not available. Hence, we use prices current at 2010, used to calculate the marine energy production value in Table 3 of the KnowSeas D4.2 Energy Sector report (Cooper, 2011), as summarised here in Annex B3. To retain consistency with the treatment of hydrocarbons in this analysis, we value renewables up to 2030. Clearly, this is a limiting assumption that under-estimates this value, even given the lifetimes of current technologies.

It should be noted that whilst the future prices of hydrocarbons are derived from modelling undertaken by IEA of future market conditions, they are strikingly similar to current prices – being within a 5% range of deviation from average 2010 prices. The inconsistency between pricing assumptions is therefore not significant in practice.

All data and calculations underlying the results reported below are presented in the accompanying file: D4.3 Energy.xls

4. Summary of Results and Discussion

The monetised, discounted results of our resource estimation exercise is reported. Whilst the core results are presented in Table 4, a number of sensitivity analyses are undertaken and reported subsequently.

The Net Present Values (NPVs) of future marine-based energy production are presented in millions of Euros in 2010 prices (real terms) in Table 4 for each resource. The NPV of future marine energy production of each resource reflects the trend in future production of each resource. The value of hydrocarbons in the EU27 constitutes 80% of the total marine-based energy production. The UK is projected to be responsible for almost 60% of hydrocarbon production and 40% of renewables in the EU27, whilst Norway's production of hydrocarbons almost doubles again the EU27 total.

Table 4. NPV of future marine energy production in Europe, €'m (2010 prices) - "maintained production scenario"

Country	Crude oil	Natural Gas	Hydro-carbons	Wind	Wave/ Tide	Renewables	Total
Denmark	97,359	35,327	132,686	6,600		6,600	139,286
France				31,714	1,572	33,285	33,285
Germany	20,886	45,940	66,825	114,334		114,334	181,159
Netherlands	9,900	326,525	336,424	84,754	507	85,260	421,684
United Kingdom	504,333	246,910	751,242	82,340	3,893	86,233	837,475
EU27 sub-total	**632,477**	**654,701**	**1,287,178**	**319,742**	**5,971**	**325,713**	**1,612,890**
Norway	789,354	459,722	1,249,076				1,249,076
Total	**1,421,831**	**1,114,423**	**2,536,254**	**319,742**	**5,971**	**325,713**	**2,861,967**

8 4% is the central discount rate used by EC DG Environment – see: http://ec.europa.eu/environment/enveco/others/pdf/proceedings.pdf. The US Dollar to Euro conversion exchange rate used is 1 Euro to 1.3257 US $ in 2010 (following conversion rates used in KnowSeas D4.2 Energy Sector spreadsheet).

As described above, an additional, more conservative, scenario based on valuing proven reserves has been utilised and the resulting NPVs are presented in Table 5. A comparison between the two sets of results shows that adoption of the more conservative assumption regarding reserves results in approximately a 30% fall in the total value of marine hydrocarbons for Europe. These results therefore highlight the dependency on hydrocarbons that these countries, and others that import from these largest producers, currently have, and the importance of implementing technologies that allow exploitation of potentially recoverable reserves.

Table 5. NPV of future marine energy production in Europe €'m (2010 prices) - "proven reserves scenario"

Country	Crude oil	Natural Gas	Hydro-carbons
Denmark	57,921	19,607	77,528
France			
Germany	12,425	25,498	37,923
Netherlands	5,890	326,525	332,414
United Kingdom	300,041	137,040	437,081
EU27 sub-total	376,277	508,670	884,946
Norway	469,607	255,156	724,763
Total	845,884	763,825	1,609,709

As recommended in standard economic appraisal, sensitivity analysis is undertaken using alternative discounting regimes. In line with DG Environment practice, discount rates of 2% and 6% are utilised around the central 4% rate and the results are summarised in Tables 6 and 7 for the maintained production scenario. Over the 20-year timeline considered here, these rates respectively increase and decrease the aggregate NPVs by approximately 20% compared to the equivalent results for 4% in Table 4 above. As would be expected, and as the accompanying spread-sheet shows, the range resulting under these discount regimes is the same for the proven reserves scenario.

Table 6. Summary NPV of Future Marine Energy Production (€m, 2010; d.r=2%) "maintained production scenario"

	Hydrocarbons	Renewables	Total	HC as % of Total
EU27	1,484,160	442,218	1,926,378	77%
EU27+Nor.	2,989,793	442,218	3,432,010	87%

Table 7. Summary NPV of Future Marine Energy Production (€m, 2010; d.r=6%) "maintained production scenario"

	Hydrocarbons	Renewables	Total	HC as % of Total
EU27	1,136,865	243,011	1,379,876	82%
EU27+Nor.	2,190,210	243,011	2,433,221	90%

As indicated in the data presented in the discussions of uncertainties above, additional sensitivity analysis is utilised to provide some testing of the robustness of the underlying socio-economic and technological drivers of the production projections. The quantitative impact of these alternative production scenarios can be summarised by applying multipliers to the results presented in Table 4. As summarised in Table 8[9], for hydrocarbons, these multipliers represent the (potentially implied) impacts on production of the two alternative IEA scenarios – "Current Policies" and "450ppm" – for 2020 and 2030, relative to the IEA New Policies" scenario on which the results in Table 4 and Table 5 are based. For wind, and Wave & Tide energy, a set of additional multipliers are derived from the scenario constructed by the European Wind Energy Association (EWEA).

Table 8. European Marine Energy Production Scenario Multipliers

Panel A Oil & Gas: Multipliers defined relative to IEA New Policies Scenario

		2015	2020	2025	2030
Oil	Current Policies	-	1.03	-	1.08
	450ppm	-	0.95	-	0.84
Gas	Current Policies	-	1.00	-	1.03
	450ppm	-	0.93	-	0.79

Panel B Wind & Wave/Tide: Multipliers defined relative to ECN Estimates

		2015	2020	2025	2030
Wind	Current Policies	-	0.80	-	0.70
	450ppm	-	1.00	-	1.40
	EWEA	1.23	1.25	0.89	0.45
Wave/tide	Current Policies	-	0.20	-	0.50
	450ppm	-	0.30	-	1.40

Source: Derived from IEA (2011), ECN (2011) and EWEA (2009)

In order to explore the influence of the scenarios on the aggregate NPV results it is perhaps most instructive to compare the results of the Current Policies scenario with the 450ppm scenario. The former scenario is primarily constructed on the basis of a relatively weak global climate mitigation energy policy that implements currently existing policies only. Results from the Current Policies scenario are presented in Table 9Table . In contrast the latter scenario assumes a rate of de-carbonisation of energy use that brings about atmospheric carbon concentration levels of 450ppm that are broadly associated with limiting global warming to 2^0C only. It follows that the use of renewables is favoured over hydrocarbons in the latter scenario relative to the former. Results from the 450ppm scenario are presented in Table 10. Perhaps most striking about the results is the fact that even when wind energy is assumed to expand, and a global policy of rapid decarbonisation is pursued, hydrocarbons still comprise almost 90% of the total NPV for EU27 and Norway. Under all three scenarios, total NPVs of marine energy to 2030 do not vary significantly for these countries – around €2.8 trillion, using a 4% discount rate.

Table 9. Summary NPV of Future Marine Energy Production (€m, 2010; d.r=4%) Current Policies scenario

	Hydrocarbons	Renewables	Total	HC as % of Total
EU27	1,304,940	240,620	1,545,559	84%
EU27+Nor.	2,575,492	240,620	2,816,112	91%

[9] Multipliers derived from data in IEA (2011) for 2020 and 2030 in Current Policies and 450ppm scenarios. Multipliers for 2015 and 2025 estimated on basis of linear interpolation between years 2010 & 2020, and 2020 & 2030 respectively.

Table 10. Summary NPV of Future Marine Energy Production (€m, 2010; d.r=4%) 450ppm/EWEA scenario

	Hydrocarbons	Renewables	Total	HC as % of Total
EU27	1,232,642	325,867	1,558,509	79%
EU27+Nor.	2,411,560	325,867	2,737,428	88%

Comparison over the results under alternative sensitivity analyses shows that, in aggregate terms, the most important assumption is that made with respect to the recoverability of available reserves.

REFERENCES

BP (2011) Statistical Review of World Energy, BP plc, June

BP (2012) Energy Outlook 2030, BP plc, January

Cooper, P. (2011) KnowSeas Deliverable 4.2 Energy Sector

ECN (2011) Renewable Energy Projections as Published in the National Renewable Energy Action Plans of the European Member States. ECN-E--10-069. Report for the European Environment Agency. Copenhagen.

EWEA (2009) Oceans of Opportunity: Harnessing Europe's largest domestic energy resource. European Wind Energy Association, September 2009.

IEA (2011) World Energy Outlook, OECD/IEA. Paris

Nakicenovic, N., Alcamo, J., Davis, G., de Vries, B., Fenhann, J., Gaffin, S., Gregory, K., Grübler, A., Jung, T.Y., Kram, T., Lebre La Rovere, E., Michaelis, L., Mori, S., Morita, T., Pepper, W., Pitcher, H., Price, L., Riahi, K., Roehrl, A., Rogner, H-H., Sankovski, A., Schlesinger, M., Shukla, P., Smith, S., Swart, R., van Rooijen, S., Victor, N. and Z. Dadi (2000) *IPCC Special Report on Emissions Scenarios. A Special Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge

Annex A: Hydrocarbon and Renewable Energy Production Forecast for EU27 Countries and Norway

Annex A1: Oil Production, ktoe

Country	2010	2015	2020	2025	2030
Denmark	12157	11920	11734	11409	11262
Germany	2608	2557	2517	2447	2416
Netherlands	1236	1212	1193	1160	1145
United Kingdom	62973	61746	60785	59098	58337
EU27 sub-total	**78974**	**77435**	**76229**	**74115**	**73159**
Norway	98562	96641	95137	92498	91306
Total	**177535**	**174076**	**171366**	**166612**	**164465**

Source: Based on calculations using BP (2012) data.

Annex A2: Natural Gas Production, ktoe

Country	2010	2015	2020	2025	2030
Denmark	7355	7965	8210	8559	9102
Germany	9565	10358	10676	11131	11837
Netherlands	63457	68720	70831	73844	78531
United Kingdom	51408	55672	57382	59823	63619
EU27 sub-total	**131785**	**142715**	**147099**	**153356**	**163090**
Norway	95717	103655	106839	111384	118453
Total	**227502**	**246371**	**253938**	**264740**	**281543**

Source: Based on calculations using BP (2012) data.

Annex A3: Offshore Wind Electricity Production, ktoe

Country	2010	2015	2020	2025	2030
Denmark	214	423	458	495	535
France	0	688	1548	3482	7835
Germany	23	688	2732	10844	43043
Netherlands	69	357	1637	7513	34489
United Kingdom	398	1618	3794	8893	20849
EU27 Total	**704**	**3774**	**10168**	**31228**	**106751**

Source: Derived using ECN (2011) data.

Annex A4: Wave and Tide Electricity Production, ktoe

Country	2010	2015	2020	2025	2030
Denmark	0	0	0	0	0
France	43	68	99	144	210
Germany	0	0	0	0	0
Netherlands	0	0	44	64	94
United Kingdom	0	0	340	495	722
EU27 Total	**43**	**68**	**483**	**704**	**1025**

Source: Derived using ECN (2011) data.

Annex B: Future Prices of Energy Resources

Annex B1: Crude oil imports price, US $/Barrel, Real terms (2010 prices)

Region	2010	2015	2020	2025	2030	2035
World	78.1	102.0	108.6	113.6	117.3	120.0

Source: IEA (2011); New Policies Scenario

Annex B2: Natural gas imports price, US $/MBtu, Real terms (2010 prices)

Region	2010	2015	2020	2025	2030	2035
Europe	7.5	9.6	10.4	11.1	11.7	12.1

Source: IEA (2011); New Policies Scenario

Annex B3: Wind, wave and tide electricity price, Million Euros/ktoe (2010 prices)

Region	2009
EU27+Norway	1.1

Source: KnowSeas D4.2

KnowSeas D4.3

Economic Valuation of European Commercial Fisheries under Good Environmental Status

B. Hutniczak[10], I. Goulding,[11] A. Münch[12]

1. Introduction

The Knowseas programme (Knowledge-based Sustainable Management for Europe's Seas) is supported by the EU 7th Framework Programme to provide a comprehensive scientific knowledge base and practical guidance for the application of the Ecosystem Approach to the sustainable development of Europe's regional seas.

Knowseas therefore complements the implementation of the EU's Marine Strategy Framework Directive, which requires EU Member States to take the necessary actions to ensure that their marine waters achieve "Good Environmental Status" (GES) by 2020. In the case of fisheries, it also reflects policy convergence with the objectives of the Common Fisheries Policy, undergoing reform during 2012, with the Member States considering the adoption of the ecosystem approach in general and maximum sustainable yield as a fisheries management target in future.

The Knowseas programme has adopted the ecosystem services methodology as a means assessing the costs and benefits of improved environmental status of European seas. Fisheries provide food security, socio-economic and recreational benefits to human populations. European seas deliver only some 40% of the net supplies of fish to the European population, and perhaps with the exception of some micro-nutritional components do not deliver significant food supply benefits. By far the most significant benefit of fisheries is the contribution of capture fisheries (and aquaculture) to socio-economic conditions, especially in more remote and fishery dependent regions of the Union.

This paper therefore focuses on assessing the economic impact of achieving Good Environmental Status in the EU's commercial capture fisheries, being one of the descriptors listed under the MSFD in terms of landed value using 2010 prices. The approach adopted is to assess the values of landings under different environmental scenarios, and use the differences between them to highlight the economic impacts of each.

Benefits of aquaculture and recreational fisheries are also significant in some EU regions. Both, but especially the latter, are also linked to healthy fish stocks. However, these benefits are addressed elsewhere.

2. Legal basis for GES in fishery sector

The technical basis for the descriptor for commercial fisheries (known as D3) is defined in detail the Annex to the Directive and in COMMISSION DECISION 2010/477/EU of 1 September 2010 "on criteria and methodological standards on good environmental status of marine waters".

[10] University of Southern Denmark, Niels Bohrs Vej 9-10, 6700 Esbjerg, Denmark (bhu@sam.sdu.dk)
[11] Megapesca Lda., Rua Gago Coutinho, Valado Sta.Quiteria, 2460 207 Alfeizerao, Portugal
[12] University of Southern Denmark, Niels Bohrs Vej 9-10, 6700 Esbjerg, Denmark

Descriptor 3 is defined as “Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock. The subsequent Commission clarifies the criteria proposes primary and secondary indicators, as shown in Table 1.

Table 1: Criteria of GES for MSFD Descriptor D3 (Commercial fisheries)

Criteria	**Primary**	**Secondary (where primary not available)**
3.1 Level of pressure of the fishing activity	3.1.1 Fishing mortality F_{msy}	3.1.2 Ratio between catch and biomass index (‘catch/biomass ratio’)
3.2 Reproductive capacity of the stock	3.2.1 Spawning Stock Biomass (SSB_{msy})	3.2.2 Biomass indices
3.3 Population age and size distribution	3.3.1. Proportion of fish larger than the mean size of first sexual maturation 3.3.2 Mean maximum length across all species found in research vessel surveys 3.3.3 95 % percentile of the fish length distribution observed in research vessel surveys	3.3.4 Size at first sexual maturation, which may reflect the extent of undesirable genetic effects of exploitation (3.3.4).

3. Current status of development of indicators

The European Commission and Member States will reach the first MSFD milestone in July 2012, when MS are required to submit first assessments of environmental status of their marine waters (Article 8), a set of characteristics for good environmental status (Article 9), a comprehensive set of environmental targets and associated indicators for their marine waters (Article 10) and monitoring programmes for the ongoing assessment of the environmental status (Article 11).

With regard to indicator D3, ICES has been requested by the Commission to provide scientific advice to the Commission and MS regarding data availability and treatment for calculation of the required indicator values, The approach to assessment of GES in commercial fisheries was set out in the Report: ICES MSFD D3 REPORT 2012, ICES ADVISORY COMMITTEE ICES CM 2012/ACOM:62 “Marine Strategy Framework Directive - Descriptor 3+, Revised 22 February 2012. This was discussed in detail with the Commission (DG MARE/ENV) and MS in Workshop held on 24/24 April 2012 (Paris). The report demonstrates the ICES approach to quantitative determination of the different indicators set out in the Commission Decision, by drawing on a case study approach in each of the EU marine basins. The study also identifies a number of methodological problems in assessing D3 using current data, which are salient for the present study. Some of the issues identified are:

Selection of stocks and species for assessment of D3 indicators should follow a series of steps, which include selection of stocks/species which make a significant contribution to catches (landings, plus discards plus IUU).

Thresholds of 1% and 0.1% are considered by ICES depending on the region. Catch threshold for inclusion of a species in assessing GES (and potentially for inclusion in assessment of costs and benefits) can therefore vary from sea to sea (depending on importance of iconic stocks and contribution to biodiversity). Care is required to avoid excluding stocks which not reach the threshold established for inclusion due to depletion by overfishing.

A draft map of the European Regional Seas as identified in the MSFD Article 4 has been prepared by EEA under context of MSFD Common Implementation Strategy WG DIKE (Data, Information and Knowledge Exchange). As far as possible this should be used to define spatial limits of European regional Seas for the purposes of assessment of costs and benefits of GES under Knowseas, to ensure output of data consistent with needs for policy decision making.

Indicators 3.1 and 3.2 are considered by ICES to be the most scientifically valid. 3.3 should only be used where data is not available. For the purpose of the economic valuation, criterion D3.1.1 (F_{MSY} as primary indicator of fishing mortality) provides the most useful basis for valuation, since it allows direct estimation of catches (which approximate to landings). Other indicators of GES do not directly allow for estimates of production.

There is substantial variation in availability of data for assessment of GES descriptors; in the case studies, approximately 122 commercial stocks in EU regional seas considered by ICES do not have sufficient data to allow reference values for fishing mortality F_{MSY} and spawning stock biomass SSB_{MSY} to be set. A review of the ICES case studies shows that although some 106 stocks (covering 75 species) are subject to advice, F_{MSY} (and this descriptor 3.1.1) could be estimated in only about 41 stocks (covering 32 species).

Table 2: Extent of data availability for Descriptor GES 3.1 (drawn from 4 ICES case studies)

Regional sea	**Scientific advice available**		**GES Descriptor 3.1 available**	
	Stocks	**Species**	**Stocks**	**Species**
Baltic	13	9	10	4
Mediterranean	48	21	c.9	9
NE Atlantic (Biscay)	32	28	16	13
NE Atlantic (Celtic area)	13	>17	6	6
	106	75	41	32

Where data is not available for D3.1 as a primary indicator of GES, no valid economic valuation of GES can be made of these stocks.

- However ICES is working on a specific methodology for estimating MSY reference points from the so-called “data poor stocks” which is expected to feed into GES assessments. The Commission is pressing MS to apply this approach, but more work is required to refine the methodology. There is a prospect that F_{MSY} may be available for more stocks in future.

- so far there has been little coordination between MS regarding shared and straddling stocks, but the MS are urged by the Commission to address this issue. Benefits derived from potentially increased yields from shared and straddling stocks will therefore need to be allocated to Member States on the basis of quota current allocations (which are based on the CFP principle of relative stability).

- until now MSY is assessed for each stock independently, irrespective of any food web linkages. There has been no attempt to apply a multi-species approach to fisheries management decisions, even though this is implicit in the ecosystem approach. However, ICES has developed a multi-species management model for Baltic. This was considered by the STECF be insufficiently robust for adoption at present, but to offer possibilities for the future. It is most likely that the Baltic will be the first regional sea for which a multi-species management approach can be adopted.

- It should be noted that ICES methodology and approach has excluded highly migratory species (eg.tunas, swordfish, sharks ie. stocks which are listed under Annex 1 of the UNCLOS). For such stocks, management advice is established by the relevant Regional Fisheries Management Organisation (RFMO). In the case of tunas for the W.Atlantic and Mediterranean this is the International Commission for the Conservation of Atlantic Tunas, which publishes estimates of F_{MSY} and B_{MSY}.

The approach set out by ICES is being applied by Member States, with a view to meeting the July 2012 deadline for the initial round of GES assessments. Ideally, to ensure a linkage of Knowseas outputs to the EU policy framework, catch valuations should be based on the GES D3.1 targets for commercial fisheries, as proposed by the MS and accepted by the Commission.

However, these are not currently available and as an alternative this study has applied ICES estimates of F_{MSY} and B_{MSY} based on the approach set out by Rainer Froese1 & Alexander Proelß "Rebuilding fish stocks no later than 2015: will Europe meet the deadline?" Reference values and yield estimates from this study were updated with the latest ICES data (where these data are available) and used to estimate the impacts of different GES scenarios for a total of 54 stocks in the European fishery sector covering the six major European marine regions.

The specific fishing zones are gathered in groups according to the list below (subzones according to ICES):

1. Arctic Waters (I, Ia, IIb, Va, Vb1, Vb2, XIVa, XIVb)

2. Greater North Sea (IIIa, IVa, IVb, IVc, VIId, VIIe)

3. Celtic Sea Ireland (VIa, VIIa, VIIb, VIIf, VIIg, VIIh, VIIj)

4. Bay of Biscay and Iberian Coast (VIIIa, VIIIb, VIIIc, VIIId, IXa)

5. Wider Atlantic (VIb, VIIc, VIIk, VIIIe, IXb, X, XII)

6. Baltic Sea (IIIb (23), IIIc (22), IIId 24, IIId 25, IIId 26, IIId 27, IIId 28, IIId 29, IIId 30, IIId 31, IIId 32)

Two additional zones are not included in valuation due to lack of data:

7. Mediterranean

8. Black Sea

4. Description of scenarios

4.1 Business as usual (BAU)

Scenario 1 (S1) assumes exploitation of the stocks under current management regime meaning continuation of harvest with the same (2010) rate over years. The harvest rate is adjusted wherever it leads to the biomass below biological safe limit (BSL). The precautionary approach implies reduction of the harvest whenever it causes stock to fall below SSB_{pa}. The stocks with no

SSB_{pa} estimates are assumed to be within BSL if biomass is at least 40% of the SSB_{MSY}. In the situation of reaching SSB_{MSY}, the harvest is assumed to continue further on at the MSY level.

4.2 No fishing until GES (Biomass at SSB_{MSY}) attained

Scenario 2 (S2) assumes cessation of the exploitation to allow stock recovery to SSB_{MSY} level and reopening with maintaining fishing mortality at F_{MSY}. This scenario represents the quickest way of complying with the MSFD, whereas is not a feasible scenario since it would imply closing certain fisheries for prolonged time periods. Note that some stocks may have suffered regime change (permanent change to stock structures due to fishing and environmental factors eg. climate change).

4.3 Fishing at F which delivers SSB_{MSY} by 2035

Scenario 3 (S3) assumes adjusting harvest rate to the maximum level delivering SSB_{MSY} in 2035 for overfished stocks. In case of stocks above SSB_{MSY} in 2011, the adjustment path assumes linear stock adjustment to SSB_{MSY} until 2035. The scenario assumes constant MSY harvest from 2035 infinitely.

5. Methodology

5.1 Estimation of biomass and harvest adjustment paths

The estimates of the Spawning Stock Biomass (SSB) giving the Maximum Sustainable Yield (SSB_{MSY}) are taken from Froese and Proelß (2011). The paper provides estimates for 54 fish stocks of the Northeast Atlantic which data on are available through the International Council for the Exploration of the Seas (ICES). The data included time series for number of recruits, SSB, total biomass, landings, fishing mortality, natural mortality, proportion of mature specimen, mean body weight per age group, age at recruitment, maximum yield per recruit with associated fishing mortality, the precautionary biomass level with associated fishing mortality and precautionary fishing mortality. The SSB_{MSY} estimates were derived using two different methods: biomass-per-recruit analysis and stock-recruitment analysis. Further calculations use equal weight average of both results.

The time (Δt) needed to increase the stock to SSB_{MSY} was derived from formula:

$$\Delta t = -\frac{\ln\left(\dfrac{2 \cdot SSB_{MSY}}{SSB_{cur}} - 1\right)}{2(F_{MSY} - F_{cur})}$$

where F_{MSY} is MSY fishing mortality, F_{cur} is current fishing mortality and SSB_{cur} is current (2011) SSB. Assuming F_{cur}=0, the equation gives as a result time of strict no fishing until reaching SSB_{MSY} (scenario 2). Rearranging the formula and assuming constant t for all stocks (24 years for scenario 3 giving SSB_{MSY} in 2035), the target fishing mortality and SSB over years is calculated.

The harvest associated with targeted SSB levels over years is derived from classic bioeconomic relation:

$$h_t = TB_t - TB_{t+1} + r_{\max} \cdot TB_t \cdot \left(1 - \frac{TB_t}{TB_0}\right)$$

where r_{max} is average maximum intrinsic growth rate derived from two methods: from slope of the stock-recruitment relationship and from surplus production analysis, TB_t is total biomass of the stock including adults and juveniles and TB_0 is total biomass of unexploited stock. Here TB_0 is calculated from:

$TB_0 = \frac{2 \cdot MSY}{0,5 \cdot r_{max}}$ and from relation $TB_t = \frac{SSB_t \cdot 0,5 \cdot TB_0}{SSB_{MSY}}$.

5.2 Determination of benefits

The benefits are calculated based on the value of the harvest for each stock assuming constant unit price at first sale. The unit price is a weighted average based on harvest in 2010, as reported by EU countries and Norway excluding Greenland and Faroe Islands (Eurostat).

The data on harvest in 2010 divided into zones originates from FishStat. In case of species represented by two or more stocks in the same region, the landings volume originates directly from ICES. The prices for estimates are assumed constant, equal to 2010 level. The benefits/initial loses associated with changes in harvest over years are assumed distributed proportionally to 2010 harvest levels both among countries and assessment areas.

The Net Present Value (NPV) for each region over 2010-2035 period was calculated using 4% discount rate[13]:

$$NPV = \sum_{t=2010}^{2035} \rho^t \left(p_{2010} \cdot h_t \right)$$

All data and calculations underlying the results reported below are presented in the accompanying file: D4.3 Fisheries.xls.

5.3 Assumptions

5.3.1 Prices and value of landings

Average prices are assumed to be maintained throughout, independently of any change in catch composition by size/quality grades etc, which we might expect to impact on prices as a result of changes in age/size structure or fish populations and any implementation of a no discard policy.

Value of landings at first sale does not account for value added (over-estimates since cost of fishing is excluded) nor for up- and down-stream multipliers (not represented). To the extent that these are compensatory, landing value is a proxy.

The calculations assume flexible switching between targeted species and positive benefits from exploitation of each stock. The significant overestimate may arise in situation when some of those stocks are actually not bring positive profits when fishing costs are deducted and in this situation there is no economic incentive to increase harvest.

5.3.2 Single-species fisheries

The approach assumes single species fisheries, so that F for a stock may vary independently from F for stocks with which, in practice, it is caught in multi-species fisheries. In practice this is not

[13] The 4% is the central discount rate used by EC DG Environment – see: http://ec.europa.eu/environment/enveco/others/pdf/proceedings.pdf

possible. Fisheries managers often make decisions having impact on fishing mortality of stocks which are not the target of the management measure.

5.3.3 Single stock management units (no interactions assumed)

The important issue not taken into consideration is interactions between different commercial fish stocks which occupy different parts of the food web, and between commercial fish stocks and other marine animals and plant life. These may not be fully understood and mutli-species fisheries management models are not yet applied in setting scientific advice for the EU fisheries managers. ICES has developed a multispecies model for the management of Baltic stocks, to account for food web effects in fisheries[14]. Although the Commission (STECF) has raised questions over its validity, it does help focus attention on the interactions commercial fish species in the Baltic.

5.4 Fishing down of stocks in excess of SSB_{MSY}

For stocks in excess of SSB_{MSY}, there is a potentially negative impact on GES, so the estimations assume that they are fished down to SSB_{MSY} by the average time that other stocks take to attain SSB_{MSY}. The model therefore considers a theoretical year in the future at which the ecosystem is nominally at equilibrium. However, the assumption may not be realistic from the efficiency point of view in the situation where costs are disregarded. In case of some stocks the arising costs may exceed profits and imply no incentives to fish down the stock in excess of SSB_{MSY}.

5.5 Impact of environmental factors

Other factors affect the recruitment of fish to a stock such as environmental factors with impact on non-fishing mortality (notably food web effects such as feed availability and predation) or oceanographic factors including climate change, impact on spawning and distribution of the stock, to the extent that spatial distribution of stock will alter. The model assumes average conditions over years, whereas extreme conditions may significantly affect stock condition and influence the expected time of reaching equilibrium. The approach adopted is to consider environmental factors to be externalities.

5.6 Discards

Current policy approach admits discards (landing records are factored by scientists to estimate catches) and may even require it in case of juvenile/over quota catch in mixed fisheries (regulatory discards). However, the CFP reform may establish new approach towards a progressive, fishery-wise, introduction of a discard ban.

The approach assumes that in future scenarios catches equals landings (ie. assumes that the no discard policy is implemented). However, in the BAU scenario, discarding may be high in some stocks, and this is not taken into account. The methodology therefore tends to undervalue the economic value of current catches.

6. Results

The final assessment due to some necessary data missing included 45 stocks which accounted in 2010 for 94% of harvest in the Baltic Sea, 76% in the Arctic Area, 33% in the Biscay Area, 62% in the Celtic Area, 72% in the Greater Atlantic and 78% in the Wider Atlantic (e.g. the stocks with no SSB assessment for 2011 were not possible to include in order to create coherent paths).

[14] See: http://www.fishsec.org/2012/03/13/ices-takes-on-multispecies-perspective-in-baltic-fisheries-management/

The BAU scenario (S1) in significantly long time horizon (e.g. 2035 for comparison) implies two major alternative results. The stocks managed in sustainable way attain SSB_{MSY} in the future, in 11 years on average (33 out of 45 stocks). The continuously overexploited stocks on the other hand present decrease to minimum assuring BSL (SSB_{pa}) (11 out of 45 stocks).

The calculated results for scenario 2 indicates, that assessed stocks require on average 3,1 years (standard deviation 2,2 years) of no fishing activity to reach SBB_{MSY} excluding 5 stocks already at SSB_{MSY} in 2011. The region specific recovery time average weighted with harvest (2010) was as follows: 2,2 years for the Baltic Sea (max 6,8 years), 1,3 year for the Arctic Area (max 4,8 years), 3,5 years for the Biscay Area (max 5 years), 1,6 year for the Celtic Area (max 7,4 years), 2,2 years for the Greater Atlantic (max 11,9 years) and 2,2 years for the Wider Atlantic (max 3 years). The detailed results are presentred in table x under t S2.

Table 3. Stocks with data available with stock situation summary, time to recovery under scenario 2 and fishing mortality under scenario 3.

Stock	SSB_{cur}/SSB_{MSY}	t S2	F S3
Herring in Sub-divisions 22-24 and Division IIIa (spring-spawners)	24%	4,0	0,21
Herring in Sub-divisions 25 to 29 and 32 minus Gulf of Riga	22%	6,5	0,12
Herring in the Gulf of Riga	78%	0,6	0,34
Herring in Sub-division 30, Bothnian Sea	248%	0,0	*
Sprat in Sub-divisions 22 to 32	90%	0,3	0,35
Cod in Sub-divisions 22 to 24	6%	6,8	0,18
Cod in Sub-divisions 25 to 32	31%	2,8	0,26
Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners)	91%	0,4	0,25
Norwegian spring-spawning herring	130%	0,0	0,16
Herring in Division VIa (North)	48%	2,3	0,23
Icelandic summer-spawning herring (Division Va)	36%	3,4	0,19
Sardine in Divisions VIIIc and Ixa	29%	5,0	0,14
Faroe Plateau cod (Sub-division Vb1)	33%	2,5	0,29
Cod in Divisions VIIe-k	29%	2,2	0,36
Cod in Sub-area IV, Divison VIId & Division IIIa (Skagerrak)	2%	11,9	0,10
Icelandic cod (Division Va)	26%	4,8	0,16
North-East Arctic cod (Sub-areas I and II)	32%	4,1	0,17
Haddock in Sub-area IV (North Sea) and Division IIIa	47%	2,0	0,28
North-East Arctic haddock (Sub-areas I and II)	146%	0,0	0,37
Faroe haddock (Division Vb)	37%	4,4	0,14
Icelandic haddock (Division Va)	41%	3,6	0,16
Haddock in Division VIb (Rockall)	29%	3,0	0,26
Haddock in Division VIa (West of Scotland)	32%	2,8	0,27
Whiting Sub-area IV (North Sea) & Division VIId (Eastern Channel)	93%	0,4	0,18
Blue whiting combined stock (Sub-areas I-IX, XII & XIV)	54%	2,8	0,16
Saithe in Sub-area IV, Division IIIa (Skagerrak) & Sub-area VI	33%	2,7	0,27
North-East Arctic saithe (Sub-areas I and II)	51%	2,3	0,21
Faroe saithe (Division Vb)	71%	1,1	0,27
Norway pout in Sub-area IV and Division IIIa	79%	0,5	0,42
Hake - Northern stock (IIIa, IV, VI, VII, VIIIa,b)	46%	2,5	0,21
Hake - Southern stock (Divisions VIIIc and IXa)	27%	3,9	0,20
Capelin, Iceland-East Greenland-Jan Mayen Area	22%	3,2	0,29
Sandeel in Sub-area IV	7%	3,8	0,36
Southern horse mackerel	125%	0,0	0,24
Western horse mackerel	125%	0,0	0,14
Plaice in Division VIIe (Western Channel)	37%	3,9	0,16
Plaice Sub-area IV (North Sea)	39%	2,8	0,22
Sole in Divisions VIIIa,b (Bay of Biscay)	29%	3,4	0,22
Sole in Divisions VIIf and g (Celtic Sea)	74%	0,8	0,30
Sole in Division VIId (Eastern Channel)	57%	1,6	0,27
Sole in Division VIIe (Western Channel)	43%	2,4	0,24
Sole in Division VIIa (Irish Sea)	17%	7,4	0,11
Sole in Division IIIa	36%	2,0	0,35
Sole in Sub-area IV (North Sea)	49%	2,6	0,20
Mackerel (combined)	96%	0,2	0,21

Under scenario 3, the SSB_{MSY} is reached in 2035 by all stocks assessed. The demanded in this case fishing mortality is presented in table 3 under F S3.

The expected changes in profits from species included in table 3 over years under scenarios 1-3 are depicted in Fig. 1.

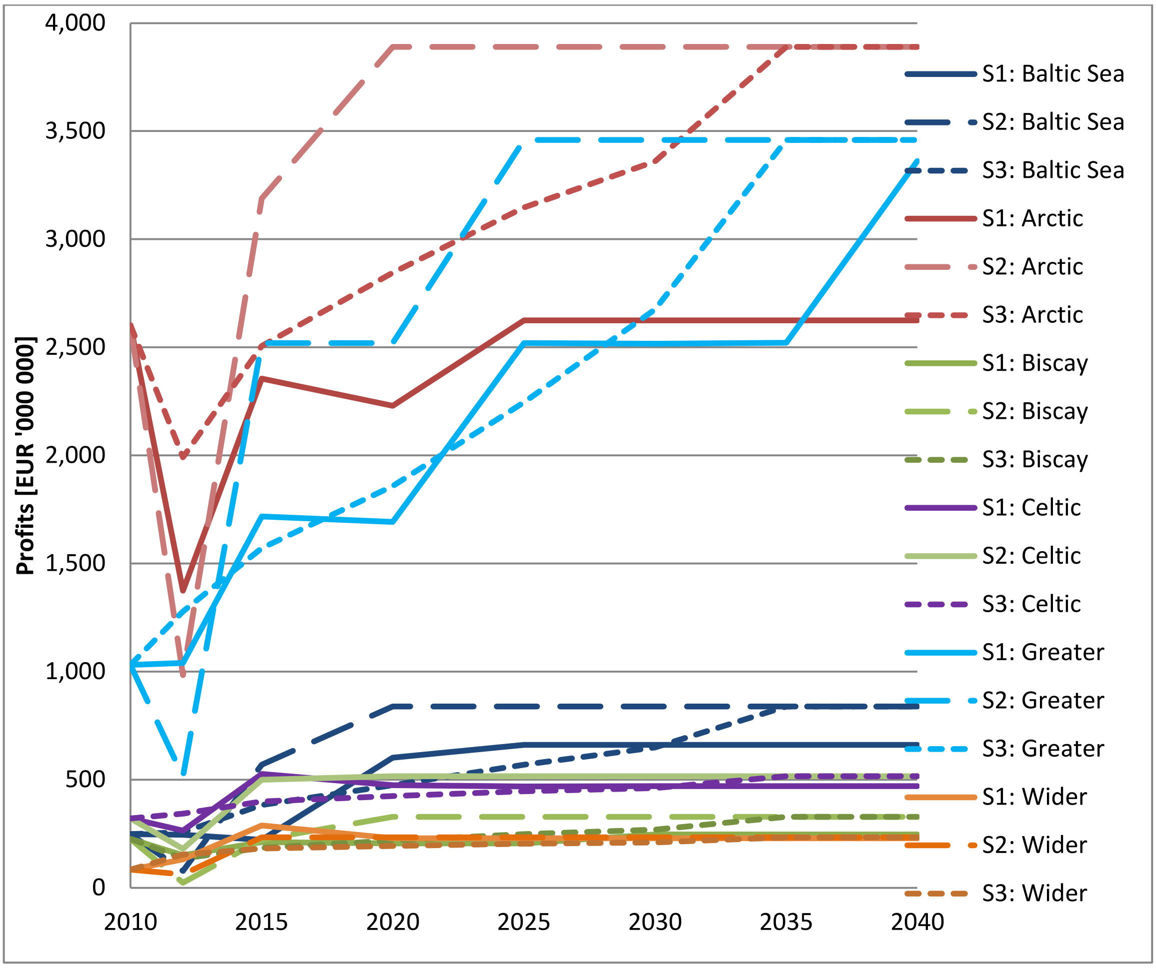

Figure 1. Results for scenarios 1-3.

Note that scenario 2 requires initial fishing of underfished stocks to SSB_{MSY} at maximum pace which is partially compensating the benefit reduction due to cessation of fishery activities in other areas. Similarly, scenario 3 requires high reduction of harvest among some stocks, whereas implies increase in harvest of so far underexploited stocks to rates above MSY. This implies the lower than expected decrease in benefits at the beginning of transition period in both scenarios. However, the model with high probability is overestimating those benefits due to difficulties to switch between exploited stocks and differences in fishing costs in different regions and using different techniques.

The table 4 gives the final overwiew of potential benefits (sum of NPV over 2010-2035) in million EUR from fishing activities in accordance to scenarios 1-3 keeping harvest of species not included in the model constant.

Table 4. NPV of regions over 2010-2035 period in million EUR.

Region	S1	S2	S3
Baltic Sea	8.791	11.542	8.831
Arctic	48.061	63.322	56.679
Biscay	15.653	16.451	15.846
Celtic	16.713	16.887	16.289
Greater	47.895	57.836	49.245
Wider	5.921	5.687	5.399

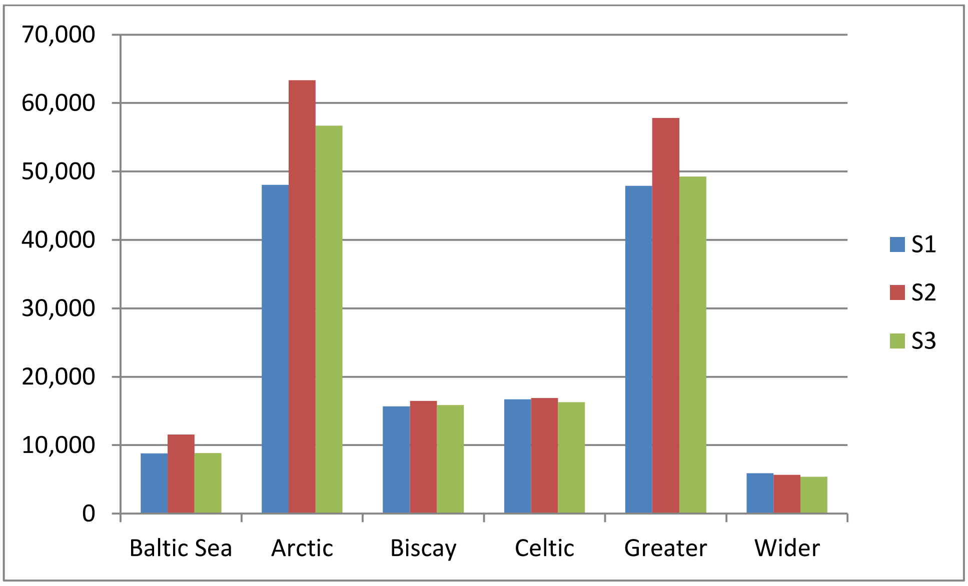

Figure 2. NPV of regions over 2010-2035 period in million EUR.

7. Discussion

7.1 Limitations of methodology

The primary limitation of the methodology is not taking into account costs of fishing. The valuation of benefits do not account for the costs of policy implementation. In most of the cases the scenario requires interim $F < F_{BAU}$ to ensure that GES is attained. This requires a reduction of catches to allow recovery. The main CFP policy instruments are quotas and effort limits and whichever applied involve reduction of incomes for current vessels, and/or fishing capacity (ie. withdrawal of vessels from the fleet). Costs not accounted for:

- loss of income
- compensation for withdrawal
- social costs to fishing communities
- cost of substitution by imports

Excluding costs of fishing activities covers up incentives behind overfishing of particular stocks and underexploitation of others. The modelled harvest allocation to available stocks may have no reflection in the real world due to asymmetry in potential gains.

In addition, there is a risk of loss of human capital as the skills base of the fishery sector is eroded.

The methodology assumes SSB_{MSY} as a target, whereas it is recommended to maintain stocks above this level to ensure sustainable harvest over years (Froese et al., 2011).

7.2 Conclusions

The methodology used in this paper has delivered the changes in potential values of the EU fisheries in six major marine regions if GES is attained by 2035 in comparison with current management regime and attaining GES right away.

Due to limitation described, it serves as a proxy to compare the final values between scenarios rather than gives actual future values due to numerous external factors affecting the fishing sector. However, it gives the scale of potential future benefits under each defined scenario.

The final conclusions imply the MSFD objectives may require significant reduction of fishing to meet MSFD targets. On the other hand, the CFP reform also aims for MSY, whereas findings raise possible policy conflict over time scale. Therefore there is a need for greater policy cohesion to ensure optimal balance of short and long term benefits.

Future work steps include:

- address costs of achieving GES
- account for timing of costs and future benefits
- assess relative costs/benefits of each scenario

REFERENCES

Froese R., Branch T.A., Proelss A., Quaas M., Sainsbury K., Zimmermann Ch. (2011), Generic harvest control rules for European fisheries, *Fish and Fisheries*, 12, 340-351

ICES (2011), Advice 2011, < http://www.ices.dk/advice/icesadvice.asp>

Fishstat < http://www.fao.org/fishery/statistics/software/fishstat/en>

Eurostat < http://epp.eurostat.ec.europa.eu/portal/page/portal/fisheries/data/database>

KnowSeas D4.3

Projected Value of Freight Transport in Europe's Seas

P. Cooper, A. Hunt and L. Anneboina
University of Bath

1. Introduction

The aim of this paper is to assess the future welfare benefits, to 2035, from the freight transport sector as a result of the use of the marine environment in Europe. This builds on the analysis of current benefits as reported in Deliverable 4.2. The paper has two sections. In the first section, we describe the data and the method used to derive monetary estimates of these welfare benefits. In the second section, we present these results, disaggregated by European sea.

2. Data and Methodology

Estimates of projected future volumes of maritime freight transport in Europe have not been published to date.[15] Consequently, we exploit forecasts of GDP and its historically close relationship with maritime freight (see Figure 1, Cooper and Anneboina, 2011) to estimate future traffic for the countries included in the scope of D4.2.

The extrapolation of the historical GDP–marine freight relationship to future time periods was undertaken through the following steps:

a. Select historical data for maritime freight volumes. This data was compiled from OECD's statistics for the EC12 countries.[16,17] Data exists for the time period 1983-2006.

b. Select historical GDP data. GDP data for the EC12 countries collectively is taken from Eurostat[18] on an annual basis from 1983 – the first year that the full freight data-set is available.[19] This regional aggregate is adopted since it both represents the demand emanating from the largest economies in the EC, and includes the leading seven countries in the EU in terms of maritime traffic in 2009 - UK, Italy, Netherlands, Spain, France, Germany and Belgium (See Table 1, Cooper and Anneboina, 2011).

c. Derive the statistical relationship between the two variables - GDP and tons of maritime freight. Ordinary Least Squares regression was used to establish the relationship between these variables in the EU, assuming that GDP is the independent variable and that freight is the dependent variable (notwithstanding the complexities of the relationship indicated above).

---

[15] Although a number of organisations - including OECD, Eurostat, International Maritime Organisation, United Nations Intergovernmental Panel on Climate Change, EC DG Mare report and/or use current and historical data, there appears to be less need for future projections of use to be made.
[16] Sea container-tonnes are taken as proxies for volumes. See http://stats.oecd.org/Index.aspx. Excludes Luxembourg since it is landlocked.
[17] OECD data was used since it provides a longer time series than Eurostat, which goes back only as far as 2002.
[18] See http://epp.eurostat.ec.europa.eu/portal/page/portal/national_accounts/documents/EC6-9-10-12%201970-2006.xls
[19] GDP data for the 7 countries individually that we are interested in is not available over this time period.

The natural logs of both variables were used in the regression analysis since the resulting coefficient can then be directly interpreted as the elasticity (i.e. % change in freight/% change in GDP (Gujarati, 1995). STATA was used to compute the results, which are presented in Table 1 along with the model diagnostics. The results indicate that a 1% increase in GDP increases freight by 1.38% with a very high degree of statistical significance.[20]

Table 2. Results and model diagnostics; Dependent variable Ln(Freight)

Source	Sum of Squares	Degrees of Freedom	Mean of the Sum of Squares		
				Number of Observations	24
				F(1, 22)	1018.88
Model	5.96	1	5.96	Prob > F	0
Residual	0.13	22	0.01	R-squared	0.979
				Adjusted R-squared	0.978
Total	6.08	23	0.26	Root MSE	0.076

	Coefficient	Standard Error	t-statistic	P>t	[95% Conf.	Interval]
Ln(GDP)	1.38	0.04	31.92	0	1.29	1.47
Constant	-9.05	0.67	-13.41	0	-10.45	-7.65

d. Extrapolation of GDP-Freight volume relationship to future time periods. The next step in the analysis is to extrapolate data on maritime freight volume costs, from current levels, (i.e. 2009, see Tables 2 and 4 respectively in the KnowSeas D4.2 report), to future time periods. As adopted in a companion D4.3 paper (Energy Sector: Future Use of the Marine Environment), GDP projections for the EU for future time periods are taken from IEA's World Energy Outlook (2011), which provides estimates out to 2035. The time periods 2015, 2020 and 2035 are used. Total GDP for Europe for these years are given as $16.8, 18.5 and 24.3 trillion (in 2010 prices), respectively. The current 2009 value is $14.9 trillion. Thus, real GDP for the EU is projected to be 12.8%, 24.2% and 36.1% larger in 2015, 2020 and 2035, respectively, than 2009.

e. Derive estimates of future freight costs. The future freight volumes calculated as above for the principal maritime freight trading countries and routes employed in D4.2 are then evaluated using the 2009 unit cost values (expressed in €/kt nautical mile (nm)) also from that source.[21] Thus, the calculation process essentially involves inflating the annual figures in the previous deliverable according to predicted freight growth associated with the IEA's GDP forecasts.

f. Aggregate total values (expressed in €m at 2010 prices) are then estimated on a discounted, present value, basis, using a 4% per annum discount rate as a central rate.[22] Alternative discount regimes of 2% and 6% are introduced in the sensitivity analysis, in accordance with EC DG Environment practice. The present values of future maritime freight costs are estimated for the period 2010-2035.[23] It should be noted that whilst projections are presented at 5-year intervals over this time period, calculations that

[20] The co-efficient is 1.37999% which is used in the calculations, although it has been rounded off to 1.38% in the text above.

[21] The countries within scope from D4.2 (Cooper and Anneboina, 2011) are Belgium, Germany, Spain, France, Italy, Netherlands, Norway and UK.

[22] 4% is the central discount rate used by EC DG Environment – see: http://ec.europa.eu/environment/enveco/others/pdf/proceedings.pdf. The US Dollar to Euro conversion exchange rate used is 1 Euro to 1.3257 US $ in 2010 (following conversion rates used in KnowSeas D4.2 Energy Sector spreadsheet).

[23] Discounted values are estimated using a discount rate of 4%. This is the central discount rate used by EC DG Environment.

underlie the final monetary values involve the use of annual estimates, which are derived from linear interpolation between the 5-year projections.

3. Results and Discussion

The future maritime freight quantities derived from application of the method outlined above are presented in Table 2. The units used are thousand tons (kt) of freight. Table 2 shows that maritime freight in the EU is projected to increase by approximately 18%, 33% and 87% in 2015, 2020 and 2035 respectively from current levels.

Table 3. Future maritime freight (kt) for the EU27 Countries and Norway

	2009	2015	2020	2035
Real GDP ($2010 trillion)	14.9	16.8	18.5	24.3
% change from current		*12.8*	*24.2*	*63.1*
Freight volume (kt)				
% change from current		*17.6*	*33.3*	*87.1*
Total EU27+NO[a]	3,615,677	4,251,934	4,821,217	6,763,477
Within scope[a]	1,986,275	2,335,804	2,648,540	3,715,521

[a] See Table 2 in Cooper and Anneboina (2011) for year 2009 amount..

Tables 3 and 4 present the future annual maritime freight costs disaggregated by European seas using the low median unit cost (€6.89 per kt nm, 2010 prices) and high median unit cost (€31.27 per kt nm, 2010 prices) respectively.[24]

Table 4. Future aggregated maritime freight costs per annum by sea - Low median values (EU-Japan route)

2010 €m	2009	2015	2020	2035
Sea				
North-east Atlantic	6,729	7,913	8,972	12,587
Baltic	6,345	7,461	8,460	11,868
Mediterranean	451	530	602	844
Black	221	260	294	413
Total	13,746	16,164	18,329	25,712

Table 5. Future aggregated maritime freight costs per annum by sea - High median values (EU-US route)

2010 €m	2009	2015	2020	2035
Sea				
North-east Atlantic	30,527	35,899	40,706	57,104
Baltic	28,784	33,849	38,381	53,844
Mediterranean	2,047	2,407	2,729	3,828
Black	1,002	1,178	1,336	1,874
Total	62,360	73,333	83,152	116,650

Two key assumptions are implicit in this approach. First, as noted in the D4.2 freight sector report, the estimates of transportation costs should be seen as representing the value attributable to the use of Europe's seas, rather than the value to Europe of exploiting its seas. However, the costs of transportation are part of the value chain that contributes to Europe's economic welfare

[24] Calculation of these freight cost estimates is explained in the D4.2 freight sector report (Cooper and Anneboina, 2011). The low estimate is based on EU-Japan route data and the high on that for the EU-US route.

and are thus taken to be a lower-bound estimate of the welfare value that can be attributed to the trade in freight considered here.

Second, by basing the estimates of future values of maritime freight in each European sea on patterns of current usage (distribution of volumes over routes), we assume that this pattern is maintained in future time periods with equal rates of growth over all routes. It should be noted, however, this assumption relies, for example, on current terms of trade being retained. Notwithstanding this, geographical patterns of trade may change significantly if, under future climate change, the Northwest Passage across Northern Canada opens up for marine freight transport moving between Europe and the Far East, as a result of reduced sea-ice. Whilst quantitative estimates of this geographical effect on freight volumes are still to be made, any significant per trip cost saving that results from opening of the Passage is likely to bring about substantial changes in these patterns.

Based on annual values interpolated from the period forecasts above, the present values are as shown in Tables 5 to 7, which are distinguished only by the application of differing discount rates. The values in Table 5 derive from application of the central rate (4%), equivalent results using 2% and 6% discount rates in Tables 6 and 7 respectively result in fluctuations of around 30% fluctuations around the results from applying the 4% discount rate.

Table 6. NPV of future maritime freight costs by sea (discount rate 4%)

2010€m	**Low**	**High**
Unit cost/€2010 per kt nm	6.8921	31.2677
Sea		
North-east Atlantic	152,982	694,040
Baltic	144,247	654,411
Mediterranean	10,256	46,527
Black	5,020	22,771
Total	312,505	1,417,749

Table 7. NPV of future maritime freight costs by sea (discount rate 2%)

2010€m	**Low**	**High**
Unit cost/€2010 per kt nm	6.8921	31.2677
Sea		
North-east Atlantic	195,696	887,824
Baltic	184,523	837,129
Mediterranean	13,119	59,518
Black	6,422	29,129
Total	399,760	1,813,601

Table 8. NPV of future maritime freight costs by sea (discount rate 6%)

2010€m	**Low**	**High**
Unit cost/€2010 per kt nm	6.8921	31.2677
Sea		
North-east Atlantic	122,806	557,140
Baltic	115,794	525,328
Mediterranean	8,233	37,350
Black	4,030	18,280
Total	250,863	1,138,097

REFERENCES

Cooper, P. and Anneboina, L. (2011) KnowSeas D4.2 Freight Transport Sector

Gujarati, D. N. (1995) *Basic Econometrics*, Third Edition, McGraw-Hill

IEA (2011) World Energy Outlook, OECD/IEA, Paris

KnowSeas D4.3

A short note on the future benefits of tourism, its drivers and consequences for marine ecosystems in Europe and Northern Africa

L. Onofri and P.A.L.D. Nunes
formerly Universita Ca'Foscari di Venezia

1. Introduction

Since World War II, the growth of international tourism has been exponential. According to the World Tourism Organization, annual tourist arrivals worldwide increased from 25 million in 1950 to 940 million in 2010. Coastal tourism is the largest and fastest-growing sector of the global tourism industry. Coastal tourism is heavily dependent on marine ecosystems, cultures and traditions of many coastal peoples that are intimately tied to the marine ecosystems, on which they depend. In Europe, the Mediterranean bases a large part of its economic activity on tourism which accounts for the one third of international tourism activity. Tourism is also highly acknowledged to have scope for economic growth in the Black Sea. Further, cultural values are also present due to the maritime civilization developed in these regions.

Besides being the largest and fastest growing sector, coastal and marine tourism are also among the oldest segments of the tourism industry. In the eighteenth and nineteenth centuries, European aristocrats, British gentry, and, gradually, wealthy Americans took leisurely "grand tours" of the Continent's natural and cultural features, including the coasts of Italy, France and Spain. With the industrial revolution, the first paid holidays and cheaper travel by railroad combined to create an annual mass exodus to seaside resorts in Europe. After World War II, mass tourism developed along European coasts. In particular, over the past four decades, mass tourism has become synonymous with the "three S's," sun, sea, sand, and has given rise to derogatory—and often accurate—stereotypes of the typical tourist.

Coastal tourism generates the positive impacts on national economies, in terms of growth and GDP and substantial values associated with tourist activities. In addition, coastal tourism is a leisure activity that generates beneficial impacts on the consumers (tourists). Nevertheless, human pressures and climate change threaten the marine and coastal ecosystems stability, reducing their capacity to provide key goods and services with high social importance.

In this short note, we focus on the analysis of the benefits of coastal tourism, its drivers and consequences for marine ecosystems in Europe. In order to do so we adopt a micro econometric approach and focus on the elements that affect the choice, therefore the demand, of coastal destination in Europe. Understanding the demand of coastal tourism, we are able to assess the value that consumers attach to marine ecosystems, when they chose their coastal destination. This is very important to understand the choice and predict future benefits deriving from coastal tourism consumption.

The note is organized as follows. Section 2 shortly explains why market demand represents the benefits from (touristic) consumption. Section 3 presents results for the empirical assessment of the demand for coastal tourism in Europe and North Africa. Section 4 concludes. The final Appendix contains technical information.

2. The Benefits of Coastal Tourism

In economics the choice of a coastal destination, therefore the (market) demand for a coastal destination, can be interpreted as a (revealed) preference for the good or service at issue. When a consumer demands a good or a service he/she reveals a preference for the good and/or service, a willingness to pay, for that good and/or service (within a well defined budget constraint) and a benefit from consumption. In our study, to examine the foundations of tourist preferences and the benefits he/she derives from coastal tourism (and marine ecosystems), we need to (empirically) study the market demand for coastal destinations. Economists record demand on a demand schedule and plot it on a graph as a demand curve that is usually downward sloping. The downward slope reflects the relationship between price and quantity demanded: as price decreases, quantity demanded increases.

In principle, each consumer has a demand curve for any product that he or she would consider buying, and the consumer's demand curve is equal to the marginal utility (benefit) curve. When the demand curves of all consumers are added up, the result is the market demand curve for that product. If there are no market failures (externalities, monopolies, public goods, asymmetric information and so on), the market demand curve is also equal to the social utility (or benefit) curve. Market demand, therefore, represents benefits derived from consumption of a particular good and service. In the case of coastal tourism, therefore, looking at the determinants that affect consumers' demand for a coastal destination, implies understanding what affects the benefits that the consumer derives from the choice of the consumption of a coastal (or a particular segment of a coastal) destination. Demand function, in fact, usually is segmented, that is, characterized by different consumers that have different willingness to pay and preferences for different characteristics for the same type of coastal tourism For the sake of the note, we are particularly interested to the effects that marine ecosystems generate, as spurring drivers for coastal demand in European and Northern African countries[25].

3. Empirical Assessment of the Demand for Coastal Tourism in Europe and North Africa

[25] Between 1969 and 1979, the World Bank encouraged developing countries to invest in tourism as a strategy for attracting foreign investment, and the governments of developing countries began to see tourism as a means to redistribute resources from North to South. The World Tourism Barometer (WTO, 2008) reports that, in the last few years, international tourism has registered a sharp increase in the number of arrivals, reaching 900 million in 2007. The Middle East has registered the highest growth rate, with an estimated 13% rise with respect to 2006. In second place stand Asia and the Pacific, with an increase of 10%, followed by Africa, registering an 8% rise to the figure of 44 million visitors in 2007. East Asia and the Pacific, Asia, the Middle East and Africa, on the other hand, are forecast to record growth rates of over 5% per year, compared to the world average of 4.1% (Honey and Krantz, 2007). Although Europe and North America remain the top destinations in international travel, representing about 65% of all international tourist arrivals, these more mature regions are anticipated to show lower than average growth rates in the forthcoming decades. In addition, tourism has become increasingly important for developing countries, accounting for 70% of exports from the Least Developed Countries (LDCs). The United Nations Conference on Trade and Development (UNCTAD) qualifies tourism as one of the main contributors to GDP of 49 least-developed countries, as well as one of the main sectors in terms of employment (Christ *et al.*, 2003). Furthermore, many of those countries host a significant share of worldwide biodiversity hotspots, including Mexico, Brazil, Thailand, Malaysia and Indonesia. However, tourism in developed countries can also have significant implications for biodiversity conservation, because biodiversity hotspots also occur in these northern destinations, such as the California Floristic Province, the northern part of Mesoamerica, the Mediterranean Basin, the Caucasus, and the mountains of south-central China. Therefore it becomes important to assess the degree to which tourism is dependent on biodiversity, in particular, among biodiversity-rich countries. This way it would be possible to shed light on the proportion of tourism's GDP contribution and its link with biodiversity, which may represent the principal tourism attraction factor.

When selecting the coastal destination, tourists choose according to both a psychological, i.e. the preference for the destination and its attributes and characteristics, and an economic dimension, i.e. the budget and time constraints. The tourists' final destination choice is not an independent decision, but instead a co-decision of a set of choices that are also determining it. The tourists' preference structures affect both the destination choice and the choice of the touristic segment, within the destination. Different tourists can demand the same destination (or type of destination), for instance a coastal destination, because of different factors that are affecting the preference structures[26]. The tourists' choice, therefore, will characterize and affect the market demand for coastal tourism, which is "segmented", because the same type of destination will be chosen for different characteristics and attributes. For example, we expect that all tourists that select coastal destinations derive satisfaction from the consumption of coastal attributes, like sun, beach and sea baths. However, we would like to dig a bit further and elicit, if possible, different demand segments, where the very same choice of the coastal destination is steered by different (main) drivers (preferences for different attributes).

Suppose, for instance, that a group of tourists choose to go on holiday to the Sardinia coasts. They all choose the very same destination. However, one can choose the Sardinia coasts mostly because of the quality of the hotels on the beach; another one because of the beautiful girls on the beach; a third one because of the naturalistic environment around the beach. The same destination (or same type of destination) choice signals a similar preference structure, across different tourists, but it can be motivated by different preferences (or preference weights attached to) for the different characteristics and attributes of the destination. The coastal touristic demand is, therefore, characterized by a horizontal product differentiation[27]. In order to capture the complex behaviour that generates the tourists' choice, the horizontal differentiation and touristic demand segmentation, our empirical strategy aims at modelling one general framework that allows to estimating different segments of the demand for the same kind of destinations. In particular, we model tourist's behaviour in terms of a set of simultaneous, interdependent decisions that we approach by the use of a 3 (or higher) stage decision process. Detailed information about data, empirical methodology and estimates for the worldwide demand of coastal tourism can be found in the Appendix[28].

Table 1 reports 3SLS results for European and Northern Africa countries for both international and domestic arrivals in 33 countries.

[26] This may depend on different factors, like personal taste, fads and fashions, marketing strategies of the destination country, recreational characteristics and attributes of the destination, among others.
[27] Horizontal differentiation of a product depends on the consumers' "subjective" valuation of the product different characteristics. Vertical differentiation, on the contrary, depends on the "objective" qualitative difference among products.
[28] See Onofri and Nunes (2012)

Table 1. EU and Northern African Coastal Tourism (Segmented) Demand

Specification	Number of Observations	(International Coastal Arrivals) "R-Squared"	(Domestic Coastal Arrivals) "R-Squared"
Equation 1	32	0.57	0.62
Equation 2	32	0.40	0.38
Equation 3b	32	0.70	0.89
Equation3b	32	0.35	0.43
		International Coastal Arrivals	Domestic Coastal Arrivals
Equation 1: (Log) Coastal Arrivals			
(Log) Total Expenditures		0.46***	0.45*
(Log) Number of UNESCO Sites		0.72*	0.35*
(Log)Number of Coastal Protected Areas		**0.53***	**0.14***
(Log) Beach Length		0.93***	0.35***
Constant		13.98***	15.99***
Equation 2: (Log) Total Expenditures			
(Log) Destination GDP per Capita		0.27*	0.25*
Population Density on the Coast		-0.12	- 0.13
Constant		4.85	4.93***
Equation 3a: (Log) Beach Length			
(Log) Annual Average Precipitation		-0.51***	- 0.48***
(Log) Harbour		-0.70***	-0.65***
Constant		-1.20*	1.00*
Equation 3b: (Log)Number of Coastal Protected Areas			
(Log) Number of Plants		0.15	0.22*
(Log) Number of Mammals		0.13	0.20*
(Log) Number of Birds		0.26	0.43
Constant		2.53	1.20

*** =statistically significant at the 1% level; * =statistically significant at the 5% level.

The estimated coefficient for the variable "total expenditures" is positive and statistically significant for both types of tourists. The results can be interpreted as the benefit (here measured in monetary terms, through a market choice that in turns reveals/signals a preference) received from consumption of the destination country. This result signals a higher availability to pay for coastal destinations from international tourists (because of higher money and time availability, or higher benefits derived from the consumption of coastal tourism). Total expenditures, in turn, positively depend on the macroeconomic milieu of the destination (measured in terms of per capita GDP) and negatively depend on the level of population density at the coast. The latter might signal that more populated areas signal "mass" touristic destinations.

The estimated coefficients for the variable "beach length" are, as expected, positive in both cases and statistically significant, demonstrating that domestic and international arrivals positively depend on the beach dimension of the selected destination. This result follows a mainstream empirical literature. However, it is worth signalling that the magnitude f estimated coefficients for international and domestic tourists is different. An important determinant of tourism destination choice is the presence of coastal areas and sandy beaches. Previous studies have demonstrated that a country's coastline and beach length positively influence the number of national tourist arrivals (Bigano et al., 2007, Maddison et. al (2007). In addition, annual average precipitation (climate related variable) and harbour dimensions (economic activities) negatively affect the attribute beach length, which, in turn, is a fundamental determinant of both domestic and international arrivals in the countries. It is important to highlight that the magnitude of the estimated coefficients for "beach length" is much larger and more statistically significant for international tourists. This result might be interpreted as a stronger preference for the European and Northern Africa "beach" segment from international tourists.

For the sake of the present note, it is important to highlight the relationship between coastal tourism demand and marine ecosystems, which are represented by the variable, "number of marine coastal protected areas". Marine coastal protected areas, in fact, are zones of the seas and coasts where wildlife is protected from damage and disturbance. They can be, however, visited by tourists in a regulated way. The Natura 2000 ecological network of protected areas in the territory of the European Union includes a wide range of marine protected areas in the North Atlantic, the Mediterranean Sea and the Baltic Sea. The estimated relationship between number of marine coastal protected areas (which, in turn, depend on a set of variables signalling environmental and biodiversity diversity) and number of arrivals is positive. Environmental and biodiversity related variables (number of plants, birds and mammals) positively affect the number of protected coastal areas by country, which, in turn, positively affects tourist arrivals in European coastal destinations. This effect is stronger among international tourists than domestic ones. It is, however, worth highlighting that the magnitude of the estimated coefficients for "beach length" is larger than the one for number of marine coastal protected areas". This result might signal the European and Northern Africa coastal destinations are mostly selected by international (mostly) and domestic tourists because of the beach amenities. Domestic tourists have a preference for the beach characteristics, in particular beach length. This in turn depends on anthropogenic pressure, built environment and climatic variables.

Finally, we consider prediction using the regression model, that is, we want to predict the value for the dependent variable (arrivals) at a given value for the explanatory variables, x0. Given that the model is assumed to hold for all potential observations, it will result that the obvious predictor for y0 = x0'*b, where b is the obtained estimate and x0'is a given value for the explanatory variables.

4. Conclusions

In this note, we have attempted to understand the determinants that explain tourists' coastal destination choice and demand in Europe and Northern Africa. Using a data set extracted from a comprehensive dataset that collects coastal arrivals worldwide together with a systematic profile of the world countries' coastline with respect to macroeconomic variables and environmental/biodiversity related indicators, the paper estimates coastal tourism's horizontal demand segments by exploring an empirical strategy that models demand function as a system of four structural equations estimated by a 3SLS routine.

Results show that marine ecosystems affect the choice of the coastal destination, especially in the case of international tourists. However, the main determinant that spurs to select European (and Northern African) coasts is the "beach length", a literature based variable that signals an amenity indicator.

Understanding the determinants that affect coastal tourism demand, therefore, understanding consumers revealed preferences, can be useful for designing proper "attractiveness" touristic and environmental protection policies, based on a better matching and compatibility between demanded and supplied coastal touristic goods and services. In particular, it would be interesting to further investigate on the obtained results. Marine protected areas in Europe (and Northern Africa) are not strong "attractors" for tourists, with respect to beach length. This might be due to a kind of "reputation" effect, since, it is diffused the idea that pristine nature and uncontaminated marine ecosystems are associated to "natural paradises" located in far oceans and exotic islands. There might be important asymmetric information among tourists. For instance, one can see the turtles that deposit their eggs on land, not only in the Caribbean islands, but also in the very European Island of Lampedusa, in Sicily. At the same time, coral reef borders the coasts of Corsica and Sardinia, besides the Australian ones. The latter point needs further investigation that goes beyond the limits of the present note.

Finally, if we have empirically assessed the benefits of tourism and the benefits generated by marine ecosystems on touristic sectors and demand, it is worth highlighting the costs generated by tourism on marine ecosystems and environment. Those costs are mostly produced by congestion and anthropogenic pressure by mass tourism. However, among the most serious threats to Mediterranean and Black Sea marine and coastal ecosystems, for instance, is pollution from urban and industrial waste as well as from agricultural runoff, and especially nutrient enrichment, particularly with nitrates and phosphates leading to eutrophication. Eutrophication manifested as decreased water transparency and disproportionate growth of filamentous algae and aquatic plants can affect people's health directly while causing losses to fisheries and recreational and touristic activities. The Black Sea is generally in a poorer state than the Mediterranean because modern environmental policies have not been sufficiently introduced, adopted or implemented across the EECCA region. Valuation studies have attributed significant economic benefits to improving the state (through implementation of proper abatement technologies) of eutrophied marine and coastal zones in the area.

The next step of the research, therefore, will focus on a careful assessing the cost of tourism on marine ecosystems.

REFERENCES

1. Baillie, J. E. M., et al., eds. 2004, (2004), IUCN Red List of Threatened Species. A Global Species Assessment. IUCN [PDF available via http://www.iucn.org/themes/ssc/red_list_2004/main_EN.htm].

2. Bigano, A., Hamilton, J. M., Lau, M., Tol, R. S. J., and Zhou, Y.: (2004), A global database of domestic and international tourist numbers at national and sub-national level, Research unit Sustainability and Global Change FNU-54, Hamburg University and Centre for Marine and Atmospheric Science, Hamburg

3. Bigano A., Hamilton J.M., Tol R.S.J. (2007), The impact of Climate Change on international and domestic tourism: A simulation study, The Integrated Assessment Journal, Vol. 7, Issue 1, pp. 25 – 49

4. CIA: 2002, The World Factbook 2002. Central Intelligence Agency, Washington, D.C., USA. (http://www.cia.gov/cia/publications/factbook.)

5. Gotelli N.J. and Coldwell R.K. (2001), Quantifying biodiversity: procedures and pitfalls in the measurement and comparison of species richness, Ecology Letters, 4 379 – 391

6. Hamilton, J. M. and Tol, R. S. J.: (2004), The Impacts of Climate Change on Tourism and Recreation, Research Unit Sustainability and Global Change FNU-52, Hamburg University and Centre for Marine and Atmospheric Science, Hamburg.

7. Hamilton J. M. (2004), Climate and the destination choice of German tourists, Nota di Lavoro 21.2004, Fondazione Eni Enrico Mattei, available on the website: http://www.feem.it/Feem/Pub/Publications/WPapers/default.htm

8. Hamilton, J. M., Maddison, D. J. & Tol, R. S. J. (2005a), 'Climate change and international tourism: A simulation study', Global Environmental Change, Vol. 15, No. 3, pp. 253–366.

9. Hamilton, J. M., Maddison, D. J. & Tol, R. S. J. (2005b), The effects of climate change on international tourism, Climate Research, 29, pp. 255–268.

10. Onofri L. and Nunes, P.A.L.D. (2012**)** Beach "Lovers" and "Greens": A Worldwide Empirical Analysis of Coastal Tourism, second round of revision Environmental and Resource Economics.

11. UNESCO: (2004),World Heritage List, UNESCO, Paris, France, Retrieved from http://whc.unesco.org.

12. Wendland K.J., Honzak M., Portela R., Vitale B., Rubinoff S., Randrianarisoa J. (2009), Targeting and implementing payments for ecosystem services: opportunities for bundling biodiversity conservation with carbon and water services in Madagascar, Ecological Economics (in press)

13. World Bank (2007) The Little Green Data Book, World Bank, Washington D.C: USA

14. World Resources Database (2003), World Resources Institute, Washington, D.C., USA

15. World Tourism Organization (2003), Yearbook of Tourism Statistics, World Tourism Organization, Madrid, Spain. ù

16. World Tourism Organization (2008), UNWTO World Tourism Barometer, Volume 6, No. 1, January 1st 2008

17. Zellner, A., and Theil, H. (1962). Three-stage least squares: simultaneous estimation of simultaneous equations. Econometrica 30 (1): 54–78.

APPENDIX

1. Datasets

Data have been gathered from a broad set of different sources with the objective to create a rich, multi-metric worldwide and comprehensive database. The bulk of the dataset, containing information about coastal arrivals (both national and international), GDP per capita at the destination country, tourists per day average expenditures and average length of stay, average annual temperature and average precipitation in 1995, is provided by the work of Bigano et al. (2004), who originally created a worldwide database, encompassing cross-sectional data for the countries under consideration. This work comprehends a unique methodology so as to disentangle coastal from land-locked arrivals, both at domestic and international level. Therefore, given the unique availability of data on coastal (international and domestic) arrivals, we concentrate the analysis on a cross-sectional 1995 dataset, and the required information that is as closer as possible to that period. Another important dimension of the dataset refers to the land-use information about each country, including the area covered by reefs and mangroves, forests and coastal wetlands. The number of (coastal) sites recorded in the World Heritage List and the number of marine and coastal protected areas for each country was retrieved from UNESCO – see Table 1. The information about anthropogenic characteristics of the destination countries coast (length of the coastline; length of the coastline destined to beaches and length of the coastline with built environment, namely harbours and cities) is gathered from the IPCC. A set of indexes measuring biodiversity is provided by different sources. According to the Convention on Biological Diversity, biodiversity is defined as *"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; this includes diversity within species, between species and of ecosystems"* (CBD, 1992). The convention foresees an obligation for each contracting party to develop national strategies and plans for the conservation of biodiversity. At the very basis of biodiversity conservation stands the need to be able to measure it and to quantify its status and trends. Since biodiversity, and the manipulation of the respective data, is rather complex to be mapped, their quantitative assessment is often done by means of indicators. In turn, there is a variety of potential biodiversity indicators and the choice of the most appropriate ones, as well as the level of detail of their measurement, depends on the objective and on the scope of the analysis under consideration. In this context, we used currently available global vector data on species ranges of mammals (Baillie et al., 2004) and birds (BirdLife International, 2006), which takes into account both the number of species per unit of area.[29] This indicator is related to community diversity and it underlies many ecological models and conservation strategies (Gotelli and Coldwell, 2001). It is a highly intuitive measure of biodiversity and it is relatively easy to compute once the scale of the analysis has been determined. Table 1 shows the full set of variables used for the empirical study, including the respective data sources and the unit of measurement. Tables 3 and 4 in the Appendix provide correlation matrixes.

From this broad dataset we have selected 32 observations for the European coastal countries, and the Northern African Mediterranean coastal countries.

[29] Due to the geographical scale of the present analysis, it was decided to focus on bird and mammal richness, testing whether these behave as flagship or charismatic species, by exerting an effect on tourist preferences and therefore the choice of their destination. Previous studies suggest that the species richness of certain indicator taxa, namely birds, may reflect that of other, more poorly studied taxa (Prendergast and Eversham, 1997). Chase et al. (2000) use birds and small mammal species as biodiversity indicators for the coastal sage scrub habitats of southern California. Noss (1990) suggests that flagship species and vulnerable species may be used as indicators of species diversity. The worldwide dataset also contained information with respect to biodiversity indexes for of amphibians, reptiles, birds, mammals and plants in the destination country, which are not here discussed since we are giving only focus on the variables that that later on revealed to play an econometric significance in explaining consumer behaviour.

Table 2. Selected Variables (Total Observations 150)

Variable	Description	Source
International Coastal Arrivals	Number of International tourists arrived at coastal destination per country in 1995	World Tourism Organization[1]
Domestic Coastal Arrivals	Number of domestic tourists arrived at coastal destination per country in 1995	World Tourism Organization[1]
Total Expenditures	Monetary expenditure per tourist in the coastal destination per country[2]	World Tourism Organization[3]
National Per Capita GDP (in USD)	Gross domestic product per capita in the Destination country in 1995	Bigano et. al (2004)
Coastal Population Density	Density of national population in the Destination country in 1995	World Resources Database
UNESCO Cultural Sites	Number of UNESCO cultural sites in the destination country in 1995	UNESCO[4]
Marine and Coastal Protected Areas	Number of Marine and Coastal protected areas in the destination country in 1995	UNESCO[4]
Beach Length	Kilometres of coastline devoted to beach uses in the destination country	IPCC
Harbour Length	Length of Harbours (measured in Kilometres) in the destination country	World Vector Shoreline (NOAA)[5]
Annual Average Precipitation	Annual average precipitation (in mm) in the destination country in the period 1961-91	IPCC
Annual Average Temperature	Annual average temperature (Celsius) in the destination country in the period 1961-91	IPCC
Area Covered by Coastal Wetlands	National territory, in the destination country, covered by coastal wetlands (measured in squared kilometres) in 2000	World Bank[6]
Area Covered by Reef	National territory, in the destination country, covered by coral reef (measured in squared kilometres) in 2000	World Bank[6]
Biodiversity Index for Mammals	Measure of biodiversity (for mammals) in the destination country in 2002	Baillie et al (2004)/ IUCN
Biodiversity Index for Birds	Measure of biodiversity (for birds) in the destination country in 2002	BirdLife International

[1]See Bigano *et al*. (2004) for the methodology so as to disentangle coastal from land-locked arrivals as well as and international from domestic arrivals; [2] Average expenditure per day times average length of stay, measured in days, per tourist in the destination country, 1995 USD; [3]Average expenditure per country per tourism and average days of stay; [4]And our own elaboration country by country; [5]http://www.ngdc.noaa.gov/mgg/shorelines/shorelines.html; [6]Plus our own investigation/elaboration country by country (national and touristic websites)

2. Econometric Analysis

One objective of analysing economic data is to predict the future value of economic variables. One approach to do this is to build a (more or less) structural econometric model, describing the relationship between the variable of interest with other economic variables/quantities, to estimate this model using a sample of data and to use it as the basis for forecasting and inference. This approach has the advantage of giving economic content to one's predictions[30].

For this reason, in order to draw conclusions about what happens when one variable actually changes, and to get the fundamental relationship among variables, we need a statistical model. Usually, we assume that there is a general relationship among variables that is valid for all possible observations from a well defined population (dataset). In our case, restricting attention for the sake of simplicity to linear relationships, we specify a statistical model as:

$$y_i = \beta_1 + \beta_2 x_{i2} + \ldots + \beta_K x_{Ik} + \varepsilon_i, \quad (1)$$

where y_i and x_i are observable variables (data), ε_i is unobserved and referred to as error term; β_1 is the constant and $\beta_{2\ldots}\ \beta_K$ are regressors or estimators, that is vectors of random variables (since the data sample may change) . By testing this general econometric model, we want to find the "best" linear approximation of the assumed (in the model) fundamental relationship and the data at our disposal. When we do so, we are able to produce estimates, vectors of numbers that represent quantitative measures to "attach" to the assumed functional form variables. Often, our statistical models are designed in order to reflect a fundamental economic relationship. This is why we adopt the "econometric" methodology: an important method that allows for statistical diagnostics of economic theory.

In our case, we can assume that there is a positive fundamental economic relationship between arrivals at coastal destinations and marine ecosystem services.

The empirical modelling strategy relies on the following behavioural reasoning. When selecting the destination, tourists choose according to both a psychological, i.e. the preference for the destination and its attributes and characteristics, and an economic dimension, i.e. the budget and time constraints. The tourists' final destination choice is not an independent decision, but instead a co-decision of a set of choices that are also determining it. The tourists' preference structures affect both the destination choice and the choice of the touristic segment, within the destination. Different tourists can demand the same destination (or type of destination), for instance a coastal destination, because of different factors that are affecting the preference structures[31]. The tourists' choice, therefore, will characterize and affect the market demand for coastal tourism, which is "segmented", because the same type of destination will be chosen for different characteristics and attributes. For example, we expect that all tourists that select coastal destinations derive satisfaction from the consumption of coastal attributes, like sun, beach and sea baths. However, we would like to dig a bit further and elicit, if possible, different demand segments, where the very same choice of the coastal destination is steered by different (main) drivers (preferences for different attributes). Suppose, for instance, that a group of tourists choose to go on holiday to the Brazilian coasts. They all choose the very same destination. However, one can choose the Brazilian coasts mostly because of the quality of the hotels on the beach; another one because of the beautiful girls on the beach; a third one because of the naturalistic environment around the beach. The same destination (or same type of destination)

[30] Another approach to prediction focuses on time series models.

[31] This may depend on different factors, like personal taste, fads and fashions, marketing strategies of the destination country, recreational characteristics and attributes of the destination, among others and.

choice signals a similar preference structure, across different tourists, but it can be motivated by different preferences (or preference weights attached to) for the different characteristics and attributes of the destination. The coastal touristic demand is, therefore, characterized by a horizontal product differentiation[32]. In order to capture the complex behaviour that generates the tourists' choice, the horizontal differentiation and touristic demand segmentation, our empirical strategy aims at modelling one general framework that allows to estimating different segments of the demand for the same kind of destinations. In particular, we model tourist's behaviour in terms of a set of simultaneous, interdependent decisions that we approach by the use of a 3 (or higher) stage decision process. First, tourists need to choose which kind of destination wish to visit. Second, tourists need to choose, within the destination, which "touristic segment" they want to consume. Third, tourists need to estimate a budget for tourism expenses and to determine frequency and length of stay of their trips, and therefore, the final destination. Formally we refer to three equations demand model that follows:

(M1) Coastal Tourism Flows = f (preference for the destination's characteristics/attributes; total expenditures; touristic market structure);

(M2) Tourists' Market Expenditures = f(macroeconomic milieu; tourism market structure; and socio-economics and demographics features of the destination country);

(M3) Preference for the characteristic/attributes of the coastal destination = f(recreational, climatic and environmental characteristics of the selected destination)

Equation (M1) refers to modelling "c*oastal tourism flows"* function and describes the total number of arrivals in a country that, in turn, are modelled in terms of the destination attributes and characteristics, including both natural and built environments, as on the total expenditures that the tourists allocate in theirs coastal destination[33]. It is worth highlighting that the preferences for the destination, in this study, are the preferences revealed by a market exchange (e.g. choice of the destination and trip to the destination; expenditures for the holiday on the destination). Equation (M2) refers to modelling "*tourists' market expenditures"* function and describes the tourists total expenditures (daily expenditures times the number of days of stay), as depending on the macroeconomic milieu, the market structure and the demographics characteristics of the destination country. The last equation, Equation (M3), or set of equations as having one for each coastal tourism segment, refers to modelling the "*Preference for the characteristic/attributes of the coastal destination"* function and describes the relationship between the coastal destination preferred tourism segment and a set of attributes and characteristics, including both natural and built environments, for each individual tourism segment. In this context, Equation (M3), or set of equations, attempt(s) to model the (horizontal) segmentation of touristic demand and the determinants of tourists' preference for the destination. Horizontal segments are, in fact, mostly generated by different appreciation for the product multi-characteristics. There will be as many *attributes based functions* as the demand segments that the researcher wants to model.

---

[32] Horizontal differentiation of a product depends on the consumers' "subjective" valuation of the product different characteristics. Vertical differentiation, on the contrary, depends on the "objective" qualitative difference among products.

[33] The function is modelled with the minimal variables requirements. It describes a relationship between number of arrivals (quantity) and total expenditures for tourism (price), describing the demand curve. It would be very interesting (and theoretically more rigorous), if it were possible from the data availability, to use variables on the tourists' income and on other goods' prices (that describes the demand function) and tourists socio-economic characteristics.

After several checks, the general model, described by Equations M1-M3 Finally, has been operationalized by the empirical model in Equations (1-3b). Data and selected variables are described in Table 2, in the Appendix. The estimation is performed via the three-stage least squares (3SLS) routine[34]

(1) $(Log)Coastal\ Arrivals_i = \beta_0 + \beta_1(Log)Total\ Expenditures_i + \beta_2(Log)MarineProtected\ Areas_i + \beta_3(Log)UNESCO\ Cultural\ Sites_i + \beta_4(Log)Beach\ Length_i + \varepsilon_i$

(2) $(Log)Total\ Expenditures_i = \beta_0 + \beta_1(Log)Destination\ GDP\ per\ Capita_i + \beta_2(Log)Coastal\ Population\ Density_i + \varepsilon_i$

(3a) $(Log)Beach\ Length_i = \beta_0 + \beta_1(Log)Annual\ Average\ Precititation_i + \beta_2(Log)Harbour\ Lenght_i + \varepsilon_i$

(3b) $(Log)Protected\ Areas_i = \beta_0 + \beta_1(Log)Number\ of\ Plants_i + \beta_2(Log)Number\ of\ Mammals_i + \beta_3(Log)Number\ of\ Birds_i + \varepsilon_i$

The model is estimated with the three stage least squared (3SLS) routine.

[34] For detailed information about the empirical methodology, see Onofri and Nunes (2012)

Table 3. Worldwide Coastal Tourism (Segmented) Demand (source Onofri and Nunes, 2012)

Specification	Number of Observations	(International Coastal Arrivals) "R-Squared"	(Domestic Coastal Arrivals) "R-Squared"
Equation 1	124	0.67	0.48
Equation 2	124	0.79	0.78
Equation 3b	124	0.42	0.49
Equation3b	124	0.55	0.53
		International Coastal Arrivals	Domestic Coastal Arrivals
Equation 1: (Log) Coastal Arrivals			
(Log) Total Expenditures		0.37***	0.03***
(Log) Number of UNESCO Sites		1.27***	0.07*
(Log)Number of Coastal Protected Areas		1.44***	0.30*
(Log) Beach Length		0.24*	2.47***
Constant		8.02***	4.41*
Equation 2: (Log) Total Expenditures			
(Log) Destination GDP per Capita		0.86***	0.87***
Population Density on the Coast		0.08	0.03
Constant		0.81	0.70
Equation 3a: (Log) Beach Length			
(Log) Annual Average Precipitation		-0.20*	- 0.26*
(Log) Harbour		-0.58***	-0.62***
Constant		2.77	1.02
Equation 3b: (Log)Number of Coastal Protected Areas			
(Log) Annual Average Temperature		0.69***	0.70***
(Log) Annual Average Precipitation		-1.08***	-1.06***
Biodiversity Index Mammals		0.11*	0.01***
Biodiversity Index Birds		0.08***	0.09***
(Log) Reef Area		0.30*	0.37*
(Log) Wetlands Area		0.23***	0.23***
Constant		2.99***	3.00*

*** =statistically significant at the 1% level; * =statistically significant at the 5% level.

KnowSeas D4.3

Water quality, recreation and carbon storage possibilities in European coastal and marine areas: trends and future perspectives

T. Luisetti[1], K. Turner[1], and Emma Jackson[2] (Section 3.2)
[1] University of East Anglia, [2] University of Plymouth-Marine Institute

1. Introduction

The EU's Marine Strategy Framework Directive 2008/56/EC contains Article 8.1(c) which calls for 'an economic and social analysis of the use of those (coastal/marine) waters and the cost of degradation of the marine environment'. From an economics perspective, the legislation can be interpreted as calling for an assessment of both the costs and benefits of society's utilisation of the coastal/marine environment and in particular the ecosystem services it provides. The arguments over the monetary pricing of nature (required in an economic analysis) or not, are now well rehearsed. Project and policy appraisal decision support systems now routinely include environmental impact assessment and the monetary value of environmental gains and losses. Newer is the debate over the introduction of welfare (damage) valuation into an accounting system to measure national economic performance and growth. Welfare analysis and damage valuation have so far been largely excluded from official national accounting systems, because of measurement problems and perceived incompatibility between damage valuation and the market pricing basis of the national accounts (Bartelmus, 2007).

Bartelmus criticises, for example, the approach used in the System for Integrated Environmental and Economic Accounting (SEEA) – 2003 on grounds of ambivalence. Even though on the one hand, SEEA stresses the need for monetary valuation of natural resources, suggesting valuation methods for 'maintenance cost' and 'damage-valuation' for valuing environmental degradation; on the other hand when compiling macro-economic indicators, it rejects valuation of environmental degradation (waste and pollution) as a matter of modelling. As a result, official accounting indicators for the full costing of environmental depletion and degradation are not yet widely available. Bartelmus (2008) advocates the use of so-called 'maintenance costs' i.e. costs that would have been incurred if the environment had been used in such a way as not to have affected its future use. In other words this is the missed opportunity of mitigating or avoiding the environmental impacts caused during the accounting period. Bartelmus (2008) therefore puts forward a supply-side valuation approach which uses cost data because of its closer compatibility with market pricing. Cost measures covering natural capital consumption, resource depletion and environmental protection (abatement) costs should be quantified and added into the national accounts in order to get a more accurate picture of the sustainability of future economic activity. Bartelmus stresses that since maintenance costs refer to environmental impacts of the current accounting period, then the accumulation of environmental impacts can be viewed as an 'environmental debt' of the current and past generations to future generations. These environmental impacts could be incorporated in the national accounts system through the maintenance cost monetisation of the impacts by weighting them according to society's compliance with environmental (emission) standards.

Benefits (welfare) measures require demand-side valuation and a range of shadow pricing methods and techniques have been developed to estimate their monetary value. Both revealed and expressed preference methods can be deployed in order to quantify the benefits provided by the ecosystem services available in the coastal/marine environment. If it is accepted that these shadow prices are valid and reliable enough for incorporation into public policy appraisal then national income accounts would come closer to measuring societal wellbeing over time. The expressed preferences (survey-based) estimates have been seen as the most controversial and for some critics the least reliable. We use both cost-based and benefits (welfare) measures in the review of some ecosystem services below.

2. Water quality and coastal and marine recreation: a future perspective

2.1 European policy and water quality in coastal areas – the Blue Flag as a proxy of future trends

There is a growing body of European legislation that is leading member states to adopt a series of indicators to monitor and restore where necessary the water quality of coastal areas to a 'good environmental status'. This is the Water Framework Directive (WFD) (2000/60/EC), which aims to protect and achieve 'good ecological status' for all surface and ground water bodies by 2015. In 2006, a new Bathing Water Directive setting new standards for inland and coastal bathing sites, which should be in full operation across the entire EU by 2015, was also adopted (2006/7/EC). The new standards include: public information about water quality and potential sources of pollution on signs and via the internet; and new parameters related to *intestinal enterococci* and *Escherichia coli* to measure water quality (DEFRA, 2011; Mansilha et al., 2009).

These are the standards or criteria set by the 'Blue Flag' program too, which started in Europe in 1987 with the purpose of encouraging beaches to comply with the EU Bathing Water Directive of 1976. In the 1980's, the criteria for a Blue Flag award to beaches and marinas covered sewage treatment and bathing water quality, but also waste management and coastal and planning protection. Since then, the criteria have become more holistic, changing with current research and technology, and have taken on an international perspective. But it was only in 1992 that the beach criteria were harmonized for all the European countries. Today, all participating countries follow the same International Blue Flag criteria for both beaches and marinas (FEE, 2007). It is worth noticing that the Blue Flag program operates independently, so that the award system cannot be influenced by local or financial interests[35]. Given the criteria required by the Blue Flag program and the purpose of this deliverable, an examination of the numbers of assigned blue flags per European country can give a sense of the strength of commitment in Europe for the sustainable development of coastal areas.

For designated beaches, the water quality is monitored by an accredited laboratory before and throughout the Blue Flag season[36], according to the set criteria. The updated bathing water quality results must be posted at the beach and sent to a National Operator to review the results for potential problems in quality or sampling frequency. If there is a water quality problem the National Operator should contact the authorities to locate and fix/remove the source of pollution (FEE, 2006).

We would assume that the growth in the economic importance of tourist recreation and the simultaneous increase in water quality requirements set by the EU, are driving European countries to gain more and more Blue Flag certifications for their beaches and marinas enhancing

[35] The composition of the International Blue Flag Jury includes: FEE Executive Board; United Nations Environment Programme (UNEP); World Tourism Organization (WTO); International Lifesaving Federation (ILS); International Council of Marine Industry Association (ICOMIA); International Union for the Conservation of Nature (IUCN); Environmental education expert; Health expert; European Union for Coastal Conservation (EUCC) (only for European countries); European Union (only for European countries).

[36] After the blue flag season (once the flags have been taken down) the National Operator should collect information for the next year, reviewing problem areas, deciding how best to progress with the campaign and start arranging seminars and meetings for the municipalities, managers and other stakeholder groups.

the possibilities for a more sustainable development of tourism in coastal areas. As shown in Figure 1, apart from Romania, Bulgaria, Slovenia, Poland, Latvia, Belgium and Malta that have a flat trend in Blue Flag awards for their beaches, all the other countries show an incremental trend in Blue Flag awards for their beaches. Spain (which owns the highest number (about 500) of Blue Flag beaches), Greece, Portugal and Denmark all show a more positive and linear trend. Although Italy and France had a sudden decline in Blue flag numbers in the first years of the 2000 they are now coming back to the mean values of the 1990's. For some Eastern European countries, beaches and water quality are still probably not a priority in their policy agenda and perhaps countries which have their coast adjacent to the Baltic Sea (Poland, and the Baltic Republics) struggle with eutrophication problems which inhibit the adoption of cost effective measures to improve their water quality. Malta probably has a limited number of beaches around its coastline. The results for the rest of the countries in the graph show that since the 1990's the European Directives on water quality are having an influence in terms of improved 'healthy' states across European beaches. We can expect that this trend will continue in the future towards the ultimate goal of a blue flag for all the main recreation beaches in Europe:

"The holistic approach to the management of coastal areas, which was gradually pursued as the Blue Flag Programme matured and expanded, has proven to be a key factor helping to turn sustainable development principles into practice. It has served as a vehicle to enhance government commitment, drive the industry beyond legislative compliance and materialize crucial public-private partnerships" (FEE, 2006).

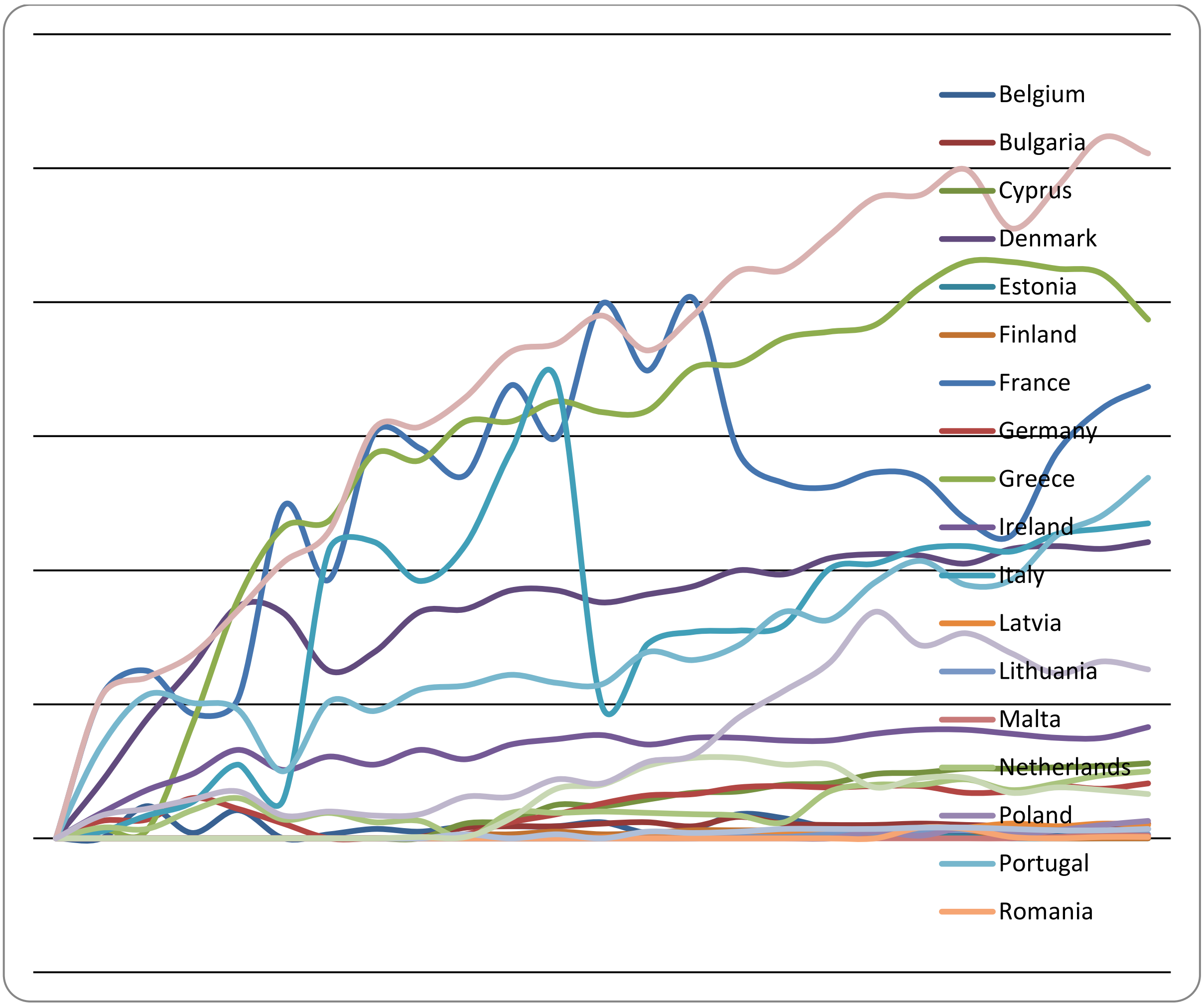

Figure 1. European Blue Flag beach numbers between: 1987-2011
Source of data: FEE – personal communication

2.2 Trends in European coastal tourism

The future of coastal tourism trends is likely to be linked to future climate change projections and forecasts. The use of coastal areas for recreation is relatively recent – 18th century – and related to cultural and socio-economic changes. Future forecasts suggest that the choice of where to enjoy recreation will be dictated by future climate. The IPCC report (2007) lists the most important impacts of climate change in coastal areas as: sea-level rise; changes in the water cycle (e.g. droughts; heavy rain; etc.); increase in global average temperature; acidification (which impacts corals); extreme weather events. Past and on-going socio-economic development make many coasts highly vulnerable to sudden environmental change and although coastal recreation goes way beyond the 3S (sun, sea and sand), the limited research on climate change impacts on coastal and marine tourism have typically focused on the few activities related to the 3S (Moreno Sanchenz, 2010). This is probably because the impact on tourism is a second-order effect preceded by the impacts on coastal ecosystem services and welfare benefits.

Globally, the Mediterranean region is still the most popular destination for (bathing) tourism. A study by the European Commission (CSIL, 2008) states that this is the area where European tourism trends are best represented. In 2005, within Europe, more than 55% of bed places were located in Mediterranean regions. In 2008, 19% of the world total of international tourists visited the Southern and Mediterranean European countries (UNWTO, 2009).

Nevertheless, it has been forecast that in the future the Mediterranean area will become too hot for tourism, whereas Northern European coasts may become more popular. In a survey-based study developed by Moreno Sanchez (2010), 28.3°C, a light breeze, and between 6 and 10 hours of sun without clouds, are the ideal weather conditions associated with beach tourism. However, it seems difficult to determine the maximum temperatures above which tourists would leave the beach and that study showed that about 72% of the respondents would still travel to the Mediterranean even if the 'ideal weather conditions' are not met there. In a study that combines 4 scenarios analysed by means of two different climate models, Moreno and Amelung (2009) find that although coasts in the north of Europe might benefit from climate change, the improvements will not be enough to attain the climatic suitability of the Mediterranean. In some scenarios possible increases in tourism growth (due to rapid global GDP growth) and the highest increase in GHG emissions are considered. In others increase in temperature and increase or decrease in precipitation are combined. Baseline conditions are represented by those of the 1970s. It is worth noticing that the authors point out that climate preferences may change in time as people get used to a warmer climate. As reported in a study of the European Union (CSIL, 2008), habits in respect to coastal tourism are changing. The typical holidaymaker in the 1960s and 70s was spending a long period of time in the same location. Currently, people prefer to escape from the cities more often during the year enjoying different activities. So, although the Mediterranean regions remain the primary bathing destination, they have also started to develop other forms of tourism connected to their coastal resources. The Black Sea is still experiencing significant increases in mass tourism, while in the other European coastal areas such as those on the Atlantic and Baltic, tourism offers combine sea-related activities together with the natural and cultural resources, and landscape of the hinterland.

A further discussion of prospects for recreation in the context of tourism is provided by an accompanying paper in Deliverable 4.3 (Onofri and Nunes, 2012).

3 Carbon storage possibilities in European coastal and marine areas: alternative futures

3.1 Introduction: a scenario analysis of carbon storage possibilities in European coastal areas

The future for carbon storage ecosystem service provision within the European coastal zone will depend on the rate, extent and characteristics (i.e. more or less sustainable paths) of future economic growth and climate change impacts. In this document we will report the current rate of degradation of saltmarshes and seagrass beds in Europe and an economic estimate of the consequences of this environmental state change. However, a scenario of continued degradation/ depletion is not the only possible future. European policies and Directives are aiming to better conserve the natural capital of ecosystems at least at their current levels, and prevent or reduce further losses. We will therefore explore other possible future scenarios too, such as increases in carbon storage provision, through re-creation of inter-tidal areas. Technically, scenarios are not probabilistic forecasts of what will happen in the future, but they should describe plausible and consistent future contexts over different spatial and temporal scales, typically 10-100 years (Andrews et al., 2005).

As highlighted in the UK National Ecosystem Assessment (NEA) (2011) scenarios are essential for ecosystem assessment. It is important to have an understanding of how the ecosystems will change in the future (and consequent gains or losses in ecosystem services) to assess how human welfare benefits will be affected. From an economics perspective, it is important to understand the value of changing a single unit of a stock. This is the strict meaning of marginal changes in economic valuation and related appraisal methods such as CBA. Although in practice it is often difficult to define precisely what is and what is not a ‘marginal’ (Turner et al, 2003).

In the D4.2 we valued the total C stock in European saltmarshes and seagrass beds. That exercise provided an estimated baseline against which future change including an apocalyptical scenario in which the entire ecosystem is lost can be compared. However, valuing total stock loss of ecosystems, as in Costanza et al. (1997), has been technically criticised in the literature (e.g. Heal et al., 2005). We use it as a baseline reference point only. It can also be argued that such a context has little policy relevance, as very few policy decisions relate to total losses of ecosystem services. Thus, what is more applicable for economic valuation and often relevant for policy decision making is an examination of incremental changes in the stock i.e. increases (e.g. conservation or re-creation measures) or decreases (e.g. losses due to pollution). The NEA (2011) suggests that the focus between feasible, policy-relevant scenarios is much more useful for decision purposes and that the following should be accomplished for an appropriate valuation of any good:

I. understanding of the change in provision of the good under consideration given changes in the environment, policies, and societal trends;
II. a robust and reliable estimate of the marginal value (i.e. per unit value);
III. knowledge of how II. might change as I. changes.

Although the NEA argues that marginal benefits of further carbon capture change in the UK are not enough to significantly ameliorate the problem of climate change, they are however more important at the European scale, and in any case they can play a useful role as one component of an overall adaptation strategy. In this deliverable we are therefore interested in estimating the loss of existing service provision, and/or the potential for increased carbon sequestration in saltmarshes and seagrass beds in the future. As highlighted by the NEA, scenarios should provide plausible, consistent but also challenging storylines that can help to understand how future decision of policy will affect ecosystems and their related ecosystem services. We will examine here the current situation based on past coastal wetland restoration and recreation policy, in line with the necessity of meeting the new EU policy targets on environmental protection; and a pessimistic scenario of continued depletion because of policy reversal, or only limited intervention and recreation schemes because of budget restrictions forced by the ongoing global financial crises. The more pessimistic scenario may also be plausible as the full extent of sea level rise becomes more apparent and coastal squeeze results in further natural habitat losses. While habitat losses due to sea level rise have been relatively small to date, i.e. estimated at 2% over the last twenty years for sand dunes in the UK and 4.5% for saltmarshes, habitat losses are projected to reach 8% by 2060 (NEA, 2011). Sea level rise predictions have also been raised and a maximum increase of, for example, 1.9m by 2095 for the UK is now considered possible (NEA, 2011).

3.2 European saltmarshes and seagrass beds area changes and related economic value of ecosystem services loss

It is now well known that coastal wetlands are globally under threat because of land reclamation, agricultural run-off, coastal development and related pollution, as well as sea level rise. It is reported in the literature that half of the global coverage of saltmarshes and about 30% of the world's seagrasses has already been destroyed (da Silva Copertino, 2011). Waycott et al. (2009) estimated a global rate of loss in seagrass of $110km^2yr^{-1}$ since 1980.

In the Mediterranean, losses of seagrasses over the last 100 years were estimated at 45 thousand ha (446 km^2 yr^{-1}) (Langmead et al., 2007). That is equivalent to more than 1 ha of seagrass per day. This is particularly relevant for *Posidonia oceanica*, the prevailing seagrass in the Mediterranean, that requires several centuries to re-grow, making its destruction practicably irreversible. In other European seas, eelgrass (*Zostera marina*) is listed as a threatened and declining habitat under OSPAR and is a sub-feature used for the designation of Special Areas of Conservation under the European Habitats Directive. *Zostera marina* was once common across sheltered European coastlines but a 'wasting disease' in the 1930s, caused by the pathogenic slime mould *Labyrinthula zosterae* led to losses of almost 90% of the *Zostera* populations. Although some beds recovered, substantial areas remain lost (Nienhuis, 1994).

Assuming that the 45 thousand ha of seagrass lost in the Mediterranean in the past 100 years is mainly *P. Oceanica*, based on our valuation (social cost of carbon equal to US$ 50/tC as per Tol (2005) and carbon sequestration potential in *P. Oceanica* of 1.82tC/ha/year – see D4.2) the lost carbon sequestration service in seagrass beds of the last 100 years equates to US$ 4.1 million. The loss per year then is roughly US$ 40 thousand (over €32 thousand[37]).

The rate of change in saltmarshes in Europe is more difficult to determine. Using the European CORINE data for this analysis and overlapping 2000 and 2006 maps, results are contradictory. As shown in Table 1, results indicate increases in saltmarsh area for all but the Mediterranean. Rather than showing the positive results of coastal realignment schemes in most of the European coastal wetlands, this may be an artefact of better mapping techniques by 2006.

Table 9. Saltmarsh areas in Europe in hectares in the years 2000 and 2006

	Mediterranean Sea	North-East Atlantic	Baltic Sea	Black Sea
2000	152,801	146,535	27,472	12,550
2006	117,893	167,673	28,855	17,612

Our analysis is limited to the differences between 2000 and 2006 because the areas covered by the 1990 dataset are significantly different (i.e. less countries were mapped). Giving this lack of precision in the data, it is difficult to give a meaningful interpretation to those results. However, in 2007 a review of loss, status and trends for coastal marine habitats in Europe suggested that approximately two thirds of all European coastal wetlands that existed at the start of the twentieth century have now been lost (Airoldi and Beck, 2007).

[37] 1 USD = 0.782982 EUR (May 2012).

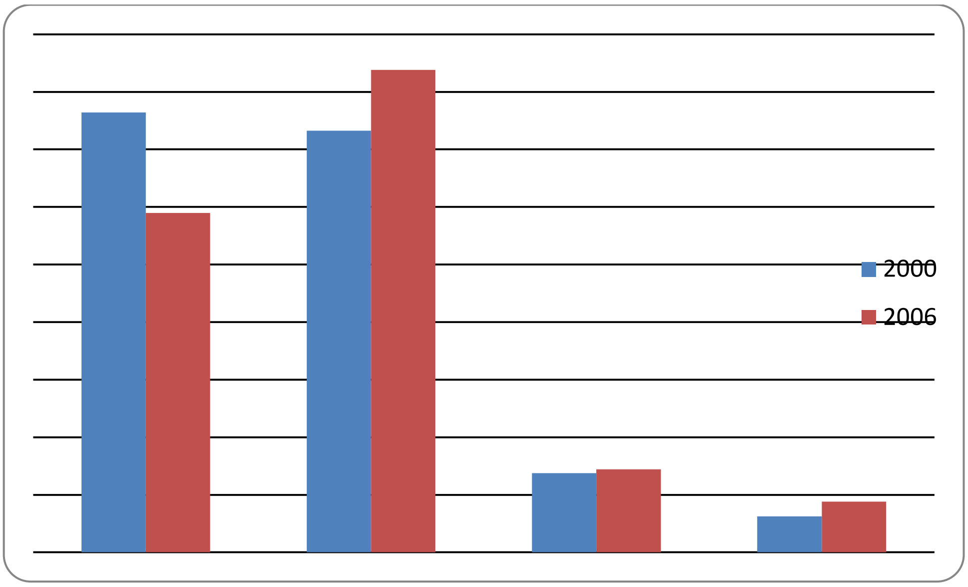

Figure 2. Changes of saltmarsh areas (ha) in Europe according to CORINE maps.

The NEA (2011) indicates that in the UK losses of saltmarshes due to sea-level rise over the past 20 years have been relatively small (4.5%). Loss of saltmarshes has been quite large prior to the 1980's mainly because of land reclamation for agriculture or urban/industrial development. Currently, because of the simultaneous action of sea-level rise and isostatic movements, major losses of saltmarshes are occurring in the south-east of England. Over the last 20 years, the UK has been trying to compensate for this habitat loss by re-creating saltmarshes via managed realignment schemes, although losses continue to exceed gains. If we assume that so far recreation of saltmarshes allowed aggregate changes in saltmarsh areas to remain relatively stable, we can imagine that in the future, fulfilling European Directives on habitat conservation, this wetland areas compensation strategy will be continued and losses will be relatively contained. Figure 2 projects the values of Table 1. Looking at Figure 2, it is probably not far from reality assuming that relatively small changes in saltmarshes, at similar rates as those estimated for the UK, have been occurring in the whole of Europe. However, because of the 2008 financial crises and its ongoing consequences, a more realistic scenario could be that in the future European states will dedicate their already scarce financial resources to more politically expedient issues than saltmarsh restoration. In this 'pessimistic' scenario, sea-level rise induced losses may dominate causing larger overall losses of ecosystem services in coastal areas.

3.3 Future scenarios of saltmarshes and seagrass beds changes in Europe and related economic valuation of carbon storage service benefits

As suggested in Section 3.2, based on the NEA (2011) data giving the rate of loss of saltmarshes in the UK and having in mind a long term horizon of 40 years (2010-2050), we assume that two future scenarios are plausible for European saltmarshes. We call these scenarios: optimistic and pessimistic. In the 'optimistic' scenario we imagine that the rate of loss will be still relatively small for saltmarshes (4.5% over 20 years) as reported in the NEA (2011); in the 'pessimistic' one, for the same temporal horizon, we will assume 4.5% decrease in the first 20 years (equal to a loss of 0.225% per annum) and a further loss at 6% for the following 20 years (equal to 0.3% per annum) - an average between 4.5% and the projected habitat loss of 8% by 2060 (NEA, 2011). In both scenarios we will imagine a continuous loss of seagrass beds of 1 ha per day. However, an 'ultra-pessimistic' scenario in which a combination of increased marine pollution and seawater temperature (Jordà et al., 2012) results by 2050 in an amount of *P. oceanica* of between 15-20% of the current habitat extent will also be considered.

According to D4.2, the total amount of saltmarshes in Europe is 330,653 ha. In the *optimistic* scenario, assuming a loss of 0.225% per annum, 744 ha of European saltmarshes are lost each year. Over 40 years time that is equal to a loss of 29,760 ha (almost 10% of existing saltmarshes). In the *pessimistic* scenario, over 40 years the loss is equal to 33,820 ha (including a loss of 947 ha p.a. calculated on the hypothetical saltmarshes existing at 2030 and a 6% loss rate over the last 20 years of the time horizon).

In both *optimistic* and *pessimistic* scenarios, assuming a future 1 ha per day loss of *Posidonia oceanica* over 40 years (years of 365 days), and as estimated in D4.2, that the extent of *P. oceanica* in the Mediterranean is 2,500,000 ha, the amount of *P. Oceanica* lost by 2050 would be equal to 14,600 ha (about 0.6% of current *P. Oceanica*). In the 'ultra-pessimistic' scenario, according to Jordà et al. (2012), by 2050 the loss of *P. oceanica* might be either 2,000,000 ha or 2,125,000 ha (respectively 80% - 85% of current extent). That is roughly equal to a loss of 50,000 - 53,125 ha per annum respectively.

Table 2 shows the present value of the loss of carbon storage potential in 40 years time (2010-2050) in both European saltmarshes and seagrass beds (*Posidonia oceanica*) given the loss rates above. Valuation of this loss is estimated using the social cost of carbon (SCC) of US$ 50/tC suggested by Tol (2005) and a 3% constant discount rate. In both *optimistic* and *pessimistic* scenarios, the present value of the loss of the carbon sequestration potential in *P. oceanica* over 40 years (2010-2050) is US$ 767,410. For the same period of time, present value losses of carbon sequestration potential in saltmarshes are higher in the *pessimistic* scenario (US$ 257,028) than in the *optimistic* scenario (US$ 238,082). The total present value of European 'blue carbon' potential loss in the *optimistic* scenario is then US$ 1,005,492 and US$ 1,024,438 in the *pessimistic* scenario. In the 'ultra-pessimistic' scenario, the value of the total present value of carbon potential loss by 2050 of *P. oceanica* is US$ 105,172,212 (20% left) and US$ 111,744,898 (15% left). The equivalent values in Euro[38] are: € 83,799,000 (20% left) and € 89, 023,000 (15% left). If the 'ultra-pessimistic' scenario became a reality, the present value loss of 'blue carbon' potential would be equal to a 0.0007% of the yearly European GDP that (at market prices) in 2011 was €12,443,563 millions (yearly European GDP in purchasing power standard per inhabitant in 2011 was €25,100).

As observed in D4.2, the carbon storage potential in *P. oceanica* is the one with the higher weight and this habitat is also the one at higher risk of depletion.

[38] 1 USD = 0.79505 EUR (28th May 2012)

Table 10. Present value of future carbon storage potential loss in 40 years (2010-2050) in European saltmarsh and seagrass beds (*Posidonia Oceanica*)

Area loss (ha) per year	Total area (ha) lost over 40 years	Carbon storage potential tC/ha/year	Hypothetical total C storage per year in the area lost	Current benefit loss of 1 year carbon sequestration potential[1]/$	Present value (2010-2050) of the carbon storage potential lost[1]/$ discount rate 3%	Present value (2010-2050) of the carbon storage potential lost[1]/$ discount rate 4%
Saltmarsh						
Optimistic scenario: 774	29,760	0.266	206	10,300	238,082	203,865
Pessimistic and ultra-pessimistic scenario: 774 (first 20 yrs) 947 (2030-2050)	33,820	0.266	206 252	10,300 (first 20 yrs); 12,600 (2030-2050)	257,028	218,131
Posidonia Oceanica						
Optimistic and pessimistic scenario: 365	14,600	1.82	664	33,200	767,410	657,120
Ultra-pessimistic scenario 50,000 (80% loss)	2,000,000	1.82	91,000	4,550,000	105,172,212	90,057,121
Ultra-pessimistic scenario 53,125 (85% loss)	2,125,000	1.82	96,687	4,834,350	111,744,898	95,685,196

[1] Evaluated at a SCC of US$50/tC

REFERENCES

Airoldi L. and Beck M. W. 2007. in *Oceanography and Marine Biology, Vol 45*, Vol. 45, pp. 345.

Andrews, J., Beaumont, N., Brouwer, R., Cave, R., Jickells, T., Ledoux, L., Kerry Turner, R. 2005. *Integrated assessment for catchment and coastal zone management: the case of the Humber*. In: J. Vermaat, L. Bouwer, K. Turner and W. Salomons (Eds.), *Managing European coasts, past, present and future*, Berlin Heidelberg New York: Springer: 323 – 354.

Bartelmus, P. 2008. *Quantitative eco-nomics: how sustainable are our economies?* New York: Springer.

Bartelmus P. 2007. *SEEA-2003: Accounting for sustainable development?* Ecological Economics, 61, 613– 616.

CSIL (Centre for Industrial Studies in partnership with Touring Servizi). 2008. *The Impact of Tourism on Coastal Areas: Regional Development Aspects*. Policy Department B: Structural and Cohesion Policies – Regional Development - Directorate General for Internal Policies of the Union.

Costanza, R., R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, S. Naeem, K. Limburg, J. Paruelo, R.V. O'Neill, R. Raskin, P. Sutton, and M. van den Belt. 1997. The value of the world's ecosystem services and natural capital. Nature 387:253-260.

da Silva Copertino, M.. 2011. *Nature* 473 (255).

DEFRA. 2011. *Bathing water newsletter*. Water Quality Division, London.

FEE, 2006, *Awards for Improving the Coastal Environment: The example of the Blue Flag*.

FEE (Foundation for Environmental Education) **-** International Blue Flag Coordination, 2007, 20 Years of Blue Flag: http://www.blueflag.org/Materiale/Publication-downloads/20thAnnPublication.pdf

Heal, G.M., Barbier, E.E., Boyle, K.J., Covich, A.P., Gloss, S.P., Hershner, C.H., Hoehn, J.P., Pringle, C.M., Polasky, S., Segerson, K., Shrader-Frechette, K. 2005. Valuing Ecosystems Services: Toward Better Environmental Decision-making. National Research Council, Washington, D.C.

IPCC. 2007. *Climate Change 2007: The Physical Science Basis. Summary for Policymakers*. Paris: Intergovernmental Panel on Climate Change.

Jordà et al. 2012. *Mediterranean seagrass vulnerable to regional climate warming*. Nature Climate Change, May, online (accessed 28 May 2012).

Langmead O., McQuatters-Gollop A., and Mee L.D. 2007. European Lifestyles and Marine Ecosystems.

Mansilha C. R., Coelho C. A., Heitor A.M., Amado J., Martins J. P., Gameiro P. 2009. *Bathing waters: New directive, new standards, new quality approach*. Marine Pollution Bulletin, 58, 1562–1565.

Moreno Sacnchez, A. 2010. Climate change and Tourism – Impacts and Vulnerability in Coastal Europe. Doctoral dissertation at the Maastricht University.

Nienhuis P. H. 1994 *Aquatic Ecology* 28 (1), 55.

Onofri, L. and Nunes, P. 2012. *A short note on the future benefits of tourism, its drivers and consequences for marine ecosystems in Europe and Northern Africa*, KnowSeas Deliverable 4.3.

Tol R.S.J. 2005. *Energy policy* 33 (16), 2064.

Turner R.K., Paavola J., Cooper P., Farber S., Jessamya V., Georgiou S. 2003 Valuing nature: lessons learned and future research directions. Ecological Economics, 46, pp. 493–510.

UK National Ecosystem Assessment. 2011. *The UK National Ecosystem Assessment Technical Report* UNEP-WCMC, Cambridge.

UNWTO. 2009. *World Tourism Barometer.* Volume 7, Number 1. Madrid: United Nations World Tourism Organization.

Waycott M., Duarte C.M., Carruthers T.J.B. et al. 2009. *PNAS* 106 (30), 12377.