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Economic impacts of the exploitation of hydrocarbons in Greece

An analysis for World Wide Fund for Nature (WWF) – Greece

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Disclaimer

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Summary

In February 2018, the Greek Parliament ratified four concession contracts for the exploration and exploitation of hydrocarbons. Oil and gas are both high value commodities, and it is believed that these concessions would benefit the Greek economy, such as increased tax revenue and employment. There are however also costs associated with oil and gas extraction, which may lead to economic loss.

Currently there is a lack of supporting evidence/analysis to understand the scale of potential costs and benefits associated with further oil and gas extraction in Greece. As the concession contracts have been ratified, there is an implicit view of the associated benefits to Greece. Therefore, this report focuses on the potential costs associated with extraction activities, in order to **provide evidence to facilitate an informed debate and ensure decision makers account for the wider costs to Greece**.

Existing studies show that the environmental impact of hydrocarbon exploitation can be severe, especially in the case of a major spill incident, and should be considered as a part of any decision-making process. Whilst this study provides some supporting information on these impacts, this assessment **focuses on the potential economic costs of exploitation activities**. This includes negative impacts to the tourism and fishing industries, costs incurred to clean-up oil spill incidents (of different sizes), and the costs of carbon emissions associated with offshore extraction activities.

To estimate these potential costs to Greece, a model was developed outlining several important parameters to the assessment. A literature review was conducted to establish an evidence base with which to model each parameter and to form assumptions where gaps in the evidence remain. Each parameter was estimated over a 25-year assessment period, with multiple pathways developed for each to allow for sensitivity testing. The sensitivity testing was conducted using a scenario approach, whereby **four plausible scenarios were developed to indicate the costs associated with a range of possible future outcomes**.

Scenario 1 provides a 'central estimate' based on what was deemed the central estimate / forecast for all variables (e.g. central estimate for oil prices, levels of oil reserves in each field and cost of extraction). Scenario 2 assumes a more positive economic outlook (e.g. higher oil prices and level of reserves and therefore for example more tax revenue and employment), whilst scenario 3 assumes a slightly more pessimistic outlook relative to scenario 1 (e.g. lower than forecasted oil price or size of oil reserve or higher cost of extraction and therefore lower taxation revenue). Under scenarios 1-3, whilst there are some minor to large oil spills over 25 years (which is strongly supported by the literature review) it is modelled that there would be no major oil spill. Under the final scenario 4, it is assumed there would be a single 'catastrophic' oil spill mid-way over a 25-year period. Each

scenario was developed based on available research to give a **rounded narrative of the context**, and general degree of benefits and costs of hydrocarbon exploitation.

Scenarios 1 through 3 **indicate potential present value costs from €0.8 billion to €1.3 billion over a 25-year period**, with scenario 4 indicating the **potential present value costs associated with a major spill to be around €5.9 billion**. The model finds that the major source of loss is to the tourism sector, followed by carbon emissions associated with extraction, and to a lesser degree, losses to the fishing sector, and costs associated with the clean-up of spills.

The average annual cost from these four impacts is estimated as €35 million to €50 million, with a one-off impact from a major spill estimated to be approximately €7.74 billion[1] (this figure is nearly 4% of Greece's current GDP). This value is largely driven by the size of the tourism sector in Greece, and the potentially **large impact a major spill event would have on inbound tourism expenditure**.

The assessment also modelled regional impacts to form a **broad estimate of the geographic distribution of the economic costs** over the 25-year assessment. The results are shown in **Table ES. 1** below.

Table ES. 1: Economic costs over 25-year period to different regions

	Scenarios 1 to 3	**Scenario 4**
Eastern Macedonia and Thrace	€5 million - €8 million	€190 million
Crete	€218 million - €304 million	€2,161 million
Epirus	€52 million - €81 million	€218 million
Ionian Islands	€513 million - €735 million	€1,784 million
Peloponnese	€48 million - €75 million	€283 million
Western Greece	€36 million - €57 million	€161 million
Central Macedonia	€11 million - €16 million	€1,147 million
TOTAL	**€883 million – €1,275 million**	**€5,943 million**

Note: The costs shown above are presented in 2017 prices and have been calculated using a 4% discount rate.

These monetised estimates account for a number of significant economic costs, but it was not possible to quantify all potential impacts. In particular, the **negative impact on the environment of Greece and its constituent regions is not included but is likely to be significant** and should be taken into further consideration as they are relevant from an ecological, moral and socio-cultural but also economic perspective. The economic relevance is related to the provision of services contributing to human well-being and economic activities – so-called ecosystem services – by the marine environment. The assessment partially accounts for damages to these ecosystem services

[1] The discrepancy between the scale of the one-off impact of a major oil spill, and the total impact of Scenario 4 which models a scenario in which a major spill occurs, is due to the effects of discounting. In Scenario 4, the major spill is assumed to occur in the mid-year of the assessment period, and is discounted accordingly, reducing the present value of the impact.

by looking at the impacts on the tourism and fishing industry, while several other ecosystem services are not accounted for due to a lack of information in existing literature. Non-assessed impacts on or related to ecosystem services include, amongst others:

- Impacts on the real estate sector benefiting from the provision of amenities and recreation support;
- Impacts on the provision of climate regulation through carbon sequestration; and
- Impacts on the provision of erosion protection.

To maximise the wellbeing of the people of Greece, its resources must be managed in a way that takes in to consideration both potential benefits and costs of any intervention, including hydrocarbon exploitation. This study begins to fill some important gaps in the evidence base needed to make informed decisions. This information should be considered alongside the expected benefits of hydrocarbon exploitation to **make decisions that are best for Greece, its environment and its people.**

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Abbreviations & Acronyms

AMECO	Annual macro-economic database of the European Commission's Directorate General for Economic and Financial Affairs
AOPL	Association of Oil Pipe Lines
BP	Name of an oil company
BSSE	The Bureau of Safety and Environmental Enforcement
BV	Dutch suffix to company name - Used for a private company with limited liability
CBA	Cost-benefit analysis
CO_2	Carbon dioxide
EEX	European Energy Exchange
EIA	United States Energy Information Administration
ELSTAT	Hellenic Statistical Authority
ESM	European Stability Mechanism
EU	European Union
FTE	Full Time Equivalent
GDP	Gross domestic product
GHG	Greenhouse gas
GVA	Gross value added
IUCN	International Union for Conservation of Nature
km	Kilometre
NPV	Net present value
OECD	Organisation for Economic Co-operation and Development
PPC	Public Power Corporation
PV	Present value
PVB	Present value benefit
PVC	Present value cost
REMPEC	Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea
S.p.A	Suffix to company name
SEA	Socio-economic analysis
SW	South-west
UN	United Nations
US	United States
W	West
WWF	World Wide Fund for Nature

1. Introduction

1.1 Background

The European Union and its Member States have committed to a phase-out of fossil fuel subsidies by 2020[2]; however, the Public Power Corporation (PPC), the predominantly state-owned Greek energy company, is continuing to invest around €4 billion a year in electricity from fossil fuels. Nevertheless, Greece has "made substantial progress in diversifying the electricity fuel mix, especially in the deployment of variable renewable energy"[3], which between 2006 and 2016 led to a decreasing dominance of fossil fuels. The share of wind power and solar power has increased from 2.8% (in 2006) to 10.5% (in 2016) and 0.3% (in 2010) to 8.1% (in 2016) respectively. As of 2016, oil has accounted for 9.9% of electricity generation in Greece, where coal (31.6%) was the primary energy source, followed by natural gas (27.8%), hydro (11.4%) and wind energy (10.5%).[4]

Despite these marked improvements in their energy mix, in February 2018 the Greek Parliament ratified three concession contracts[5] for the exploration and exploitation of hydrocarbons[6] which risks shifting the energy mix balance back towards the reliance on fossil fuels (rather than increasing the use of renewable energy sources). These concessions, shown in **Figure 1.1** with other concession areas currently leased or in operation, are in line with the Hellenic Hydrocarbon Resources Management's[7] focus on promoting larger surface concessions for the exploration and exploitation of hydrocarbons in Greece[8]. The concessions have been granted with the aim of reengaging the oil sector, which has experienced several years of economic stagnation[9]. Greece's plans for future development of the oil and gas sector include granting concessions for the contract areas presented in **Table 1.1**[10]. Estimates suggest that Energean, currently Greece's only offshore oil producer, produces 3,500 barrels per day in the northeast region of the country[11]. By comparison, production of crude oil was estimated at 560 barrels/day in Egypt (2018), 57 barrels/day in Turkey (2018) and 0.39 barrels/day in Israel (2018)[12].

[2] *Worrall, L. and M. Runkel. (2017). Monitoring Europe's fossil fuel subsidies: Greece. Retrieved from: https://www.odi.org/publications/10938-monitoring-europes-fossil-fuel-subsidies-greece*
[3] *International Energy Agency. (2017). Energy Policies of IEA countries: Greece – 2017 Review. Retrieved from : https://www.iea.org/publications/freepublications/publication/EnergyPoliciesofIEACountriesGreeceReview2017.pdf, p. 61*
[4] *Ibid.*
[5] *A concession contract is a grant of rights or land from government to a corporation, in this case the right to exploit hydrocarbon resources.*
[6] *Organic compounds of hydrogen and carbon atoms, including crude oil and natural gas.*
[7] *The Hellenic Hydrocarbon Resources Management (HHRM), formed in 2011, is a responsible for organizing and executing all exploration tenders, appointing contracts and overseeing exploitation activities. Although HHRM is state owned, it operates independently as a private-sector economic entity.*
[8] *Oikonomopoulos, K., Makrodimitras, G. and Y. Bassias. (2018). Greece offers new offshore exploration opportunities. Retrieved from: https://www.ogj.com/articles/print/volume-116/issue-2/general-interest/greece-offers-new-offshore-exploration-opportunities.html*
[9] *Dunnahoe, T (2017). Greece opens up frontier Ionian Sea, south of Crete exploration. Retrieved from https://www.ogj.com/articles/print/volume-115/issue-8/special-report-offshore-europe/greece-opens-frontier-ionian-sea-south-of-crete-exploration.html*
[10] *WWF Greece. (2018). Hydrocarbon frenzy in Greece.*
[11] *https://uk.reuters.com/article/uk-greece-energy-hydrocarbons/greece-to-open-up-onshore-oil-and-gas-prospects-in-2018-licensing-authority-idUKKBN18P1DB*
[12] *https://tradingeconomics.com/country-list/crude-oil-production*

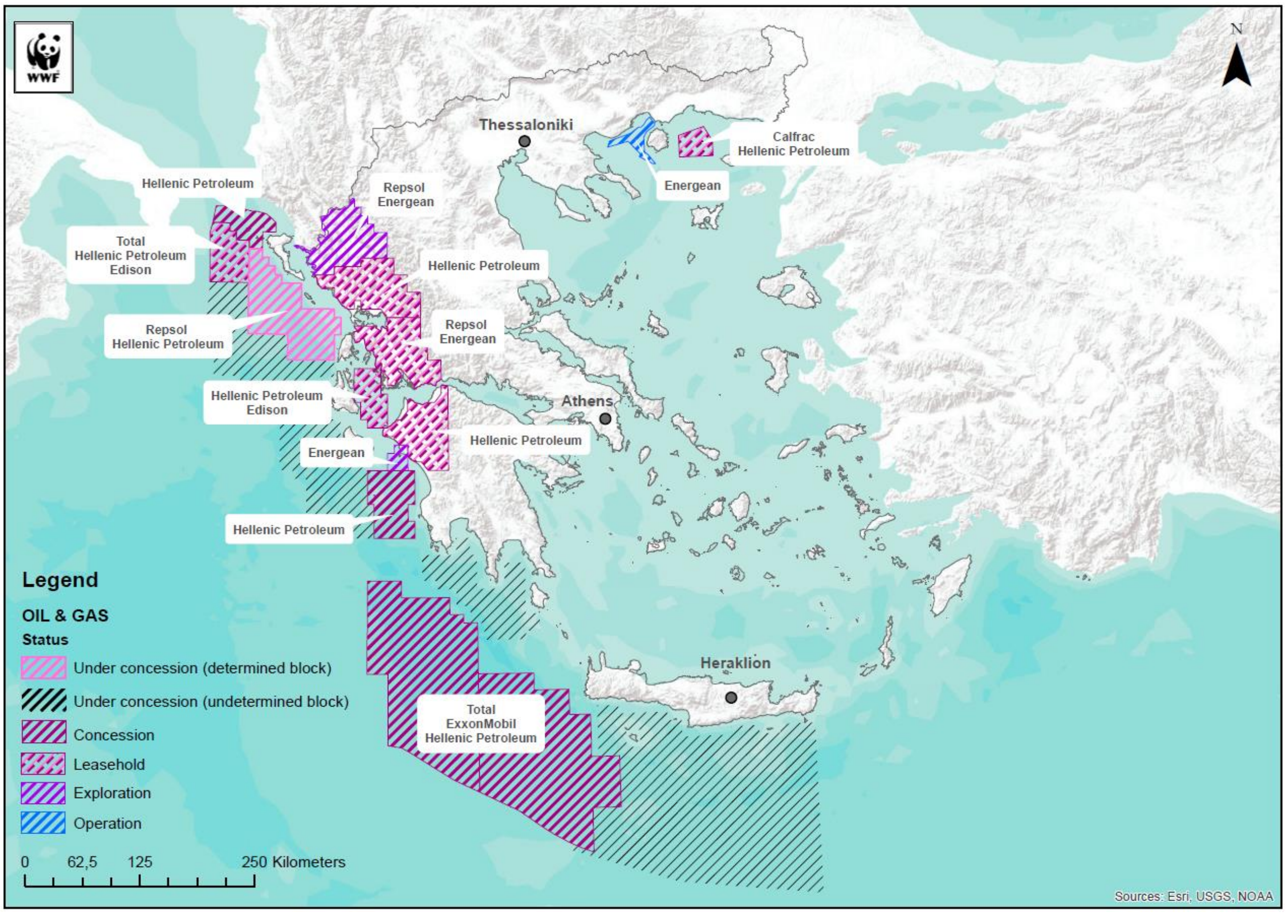

Figure 1.1: Concession areas currently leased or in operation

Source: WWF Greece. (2018). Based on: Hellenic Hydrocarbons Resource Management company.

Table 1.1: Greece's national plans for the development of oil and gas concession areas

Contract Area	Companies	Area (km^2)
Ioannina	Energean Oil & Gas, Petra Petroleum and Schlumberger (since 2017; Repsol)	4,187
Ionian Block	Repsol, Hellenic Petroleum	6,671
Patraikos Gulf	Edison, Hellenic Petroleum	1,892
SW and W of Crete	Total, ExxonMobil, Hellenic Petroleum	19,868 (SW) 20,058 (W)
Katakolon	Energean Oil & Gas	545
Arta-Preveza	Hellenic Petroleum	4,762
Aetoloakamania	Repsol, Energean	4,360
NW Peloponnese	Hellenic Petroleum	3,778
Sea of Thrace	Calfrac and Hellenic Petroleum	1,600
Block 1	Hellenic Petroleum	1,801
Block 2	Total, Hellenic Petroleum, Edison	2,422
Block 10	Hellenic Petroleum	3,420

Although technological improvements have led to a decreasing tendency for oil and gas industry accidents in European Waters[13], engagement in hydrocarbon exploration and extraction activities are still associated with real risks, which may take multiple forms including:

- Direct risks from operations and accidents (i.e. oil spills);
- Climate change risks and costs (i.e. incompatibility with the Paris agreement);
- The creation of 'stranded assets' (i.e. investments which become unrealisable due to changing circumstance, such as new regulations, a shift in demand, or legal action); and,
- Opportunity costs (i.e. the potential for better returns from investing in alternative activities, such as renewable energy or energy efficiency measures).

With major oil spills now a rare event, the impact of small and medium size spills and their effect on pollution is becoming increasingly important both in the short and long term. Between 1999 and 2004 alone, more than 9,000 oil slicks were reported in the Mediterranean Sea, the vast majority of which were small incidents[14]. Past oil spill incidents have illustrated that hundreds of kilometres of coastal ecosystems can be affected. The *Prestige* oil spill – a tanker incident near the coast of Spain – resulting in the spillage of 64,000 metric tons of oil for example polluted more than 1300 kilometres of coastline[15], while the *El-Jiyeh* oil spill in Lebanon in 2006 resulting in the release of 15,000 tons of oil into the Mediterranean Sea affected the coastal area on a length of 150 kilometres[16]. Due to high maritime traffic, as well as geographic characteristics such as higher water depth and seismic activity, Greece has been found as leading a relatively high risk of oil spill in comparison to other European locations[17]. Further information on this area of research can be found in **Annex A**.

The increased risk of oil spill in Greece, and its impact, is pertinent due to the critical importance of the Greek landscape to biodiversity. There are over 400 *Natura 2000 Network*[18] sites in Greece[19], representing a coordinated network of protected areas for biodiversity and conservation. Furthermore, the Greek peninsular is a highly heterogeneous environment, hosting a high diversity of species and ecosystem types. The 2018 concession areas specifically include several critically important protected sites, including the National Park of Northern Pindos (Ioannina), the Natural Marine Park of Zakynthos (Ionian) and the Ramsar Wetlands of Messolongi, Amvrakikos and Kotychi-Stofillia[20] (see **Figure 1.2**). Similarly, a number of protected species have been recorded in the concession areas, particularly the Ionian and the Hellenic Trench, including the Mediterranean monk seal (*Monachus monachus*), the sperm whale (*Physeter microcephalus*), and the loggerhead sea turtle (*Caretta caretta*), all of which are listed as 'critically endangered' on the International Union for Conservation of Nature and Natural Resources (IUCN) Red List.

[13] *European Parliament. (2013). The impact of oil and gas drilling accidents on EU fisheries. Brussels: Aberdeen Institute for Coastal Science and Management, p.11*

[14] *Ferraro, G., Roux, M., Muellenhoff, O., Pavliha, M., Svetak, J., Tarchi, D. and K. Topouzelis. 2009. Long term monitoring of oil spills in European seas. International Journal of Remote Sensing, 30(3), 627-645, cited in: European Parliament. (2013). The impact of oil and gas drilling accidents on EU fisheries. Brussels: Aberdeen Institute for Coastal Science and Management.*

[15] *Loureiro, M.L., Ribas, A., López, E. and E. Ojea. (2006). Estimated costs and admissible claims linked to the Prestige oil spill. Ecological Economics, 59, 48-63. doi: 10.1016 /j.ecolecon.2005.10.001, p.48*

[16] *UNDP Lebanon. (2014). Report on the measurement & quantification of the environmental damage of the oil spill on Lebanon.*

[17] *European Parliament. (2013). The impact of oil and gas drilling accidents on EU fisheries. Brussels: Aberdeen Institute for Coastal Science and Management, p.11*

[18] *Natura 2000 is the largest coordinated network of protected areas in the world. The aim of the network is to ensure the long-term survival of Europe's most valuable and threatened species and habitats. Natura sites are designated under two European directives: Habitats Directive and Birds Directive.*

[19] *Dimopoulos, P., Drakou, E., Kokkoris, I., Katsanevakis, S., Kallimanis, A., Tsiafouli, M., Bormpoudakis, D., Kormas, K. and Arends, J., 2017. The need for the implementation of an Ecosystem Services assessment in Greece: drafting the national agenda. One Ecosystem, 2, p.e13714.*

[20] *WWF Greece. (2018). Hydrocarbon frenzy in Greece.*

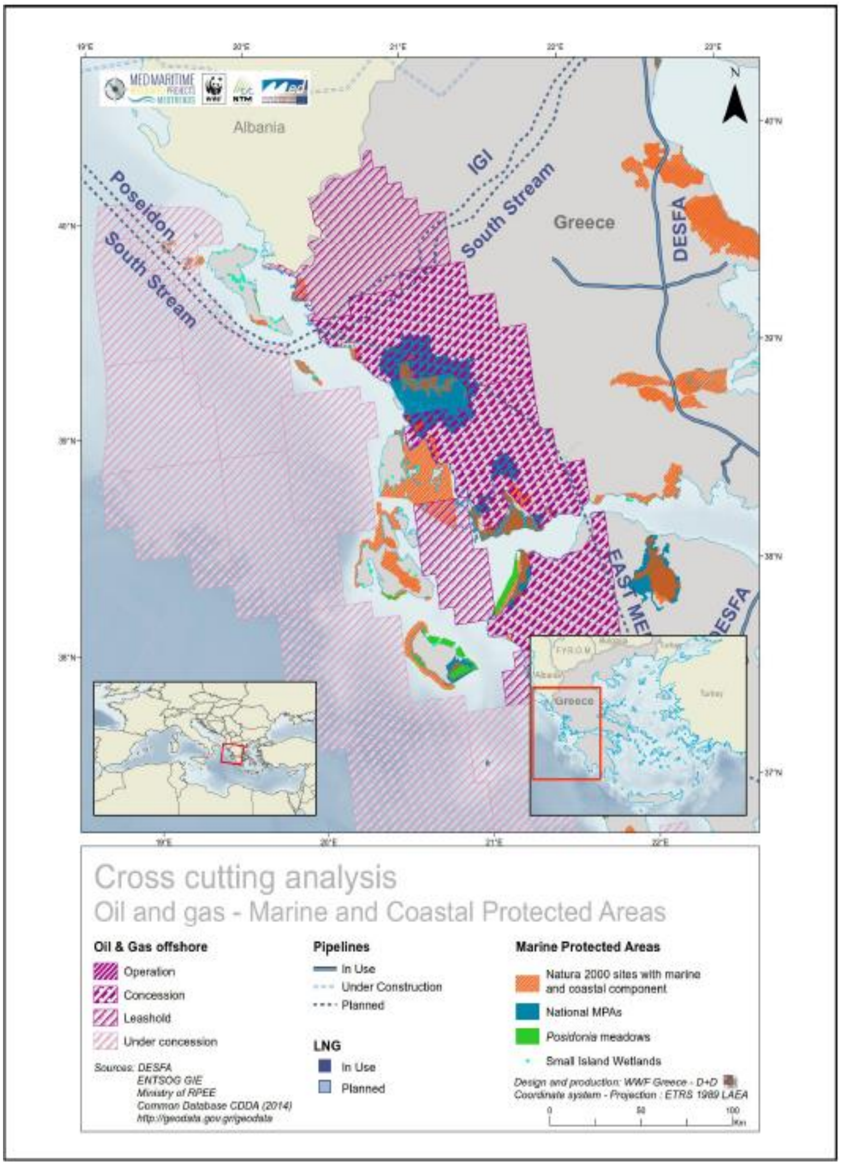

Figure 1.2: The oil and gas concession areas highlighted against protected habitat

The risk of accident in the concession areas also has the potential to significantly impact Greek Industry. The tourism industry for example, which relies upon a wealth of natural resources, was estimated to represent approximately 20% of Greece's GDP in 2017 (€ 35 billion) and provide 459,000 jobs (12% of total employment)[21]. Another estimation, from the Greek Tourism Confederation[22], posits that tourism contributes between 22.6% and 27.3% of GDP in 2017, if accounting for indirect supply chain impacts. Similarly, the fishing industry, with a fleet of 16,000 vessels and an estimated marine catch of 63,600 tonnes in 2013[23], is also reliant on the marine environment which is at risk from oil spills. Some regions may also be disproportionally affected, for example, tourism represents more than 70% of regional GDP in the Ionian Islands region, and 47.4% of Crete's GDP[24]. Similarly, the fishing industry contributed € 230.2 million and € 109.0 million to Central Macedonia and Peloponnese respectively in 2005[25].

[21] *World Travel & Tourism Council - TRAVEL & TOURISM ECONOMIC IMPACT 2018 WORLD*
[22] *SETE Intelligence, 2018. Retrieved from: https://sete.gr/media/10888/2018_symvolhtourismou-2017.pdf.*
[23] *FAO Fisheries and Aquaculture Country Profiles: Greece. Retrieved from http://www.fao.org/fishery/facp/GRC/en*
[24] *Ibid.*
[25] *European Parliament, 2007. Regional Dependency on Fish. Policy Department – Structural and Cohesion Policies.*

1.2 Objectives

Environmental organisations including WWF Greece are raising concerns about the uptake oil and gas extraction at the concession sites. It is critical that the government, and the general public at large, are able to make informed decisions, and to take into account the long term economic, environmental, human health and social consequences of their decisions. However, there is a lack of analysis of the concession areas broader economic costs and benefits, or it is not publicly available.

The purpose of this study is to provide an independent economic assessment to generate information on the negative impacts of hydrocarbon exploitation in the off-shore concession areas of Greece. When making informed decisions, both the benefits and costs of an intervention should be considered. This report builds evidence on the potential costs of hydrocarbon exploitation to inform the decision-making process. While negative impacts result from both on-shore and off-shore oil and gas extraction, the current assessment focuses on off-shore extraction due to the considerable differences in the cost typology of land-based ecosystems and economic activities.

In the absence of other evidence, the results from the study are intended to inform discussion around hydrocarbon exploitation, through triggering debate on broader economic impacts, and in the process to help identify omissions in the current understanding of the potential impacts, and make progress towards addressing these omissions. Raising awareness and fostering public debate on the costs and benefits of hydrocarbon exploitation in Greece, may reveal more accurate information which is key to determining whether it is worthwhile for Greece to pursue this area of economic development.

1.3 Scope

The scope of this project is to build a model of the potential impacts to Greece from off-shore hydrocarbon exploitation, focusing on the cost of wider economic impacts. The assessment is developed around the analysis of four different scenarios which allows for the accounting of uncertainty through sensitivity testing of various parameters of the model. The scenarios represent a set of plausible future outcomes based on current evidence, but the model has been developed to be adjustable should future understanding of potential impacts improve, or more data becomes available.

The report covers the approach to modelling, the development of the scenarios, the results from the analysis, and a discussion of their implications. The appendices contain research on the literature around the impacts of hydrocarbon exploitation and a description of the development of a cost-benefit analysis (CBA) model to assist the assessment.

1.4 Report Structure

The remainder of this report is structured as follows:

- **Section 2** discusses the approach that has been undertaken, which includes data review and analysis, development of an impact model and the testing of four scenarios;
- **Section 3** introduces the four scenarios in more detail and provide reference as to why these scenarios were determined as plausible;
- **Section 4** presents the results of the analysis for each scenario;
- **Section 5** presents the results of the analysis for each region;

- **Section 6** discusses the findings from the study, limitations relating to the model, and the implications of the findings for hydrocarbon exploitation in Greece;
- **Annex A** covers the research conducted to inform the model based on a review of the relevant literature; and,
- **Annex B** describes the formulaic approach to modelling and its limitations.

2. Approach

2.1 Methodology

The assessment is an economic appraisal of the costs of hydrocarbon exploitation in Greece over time, based on a range of plausible development scenarios. The approach allows for the comparison of costs in the same unit of measure, money, to gain understanding of their relative scale. The information generated can be used in supporting decision making regarding whether the intervention is a sound investment for Greece, considering the effects in economic activity at the national and regional level.

The analysis conducted considers the development of hydrocarbon exploitation in Greece relative to the absence of such development. A 25-year time horizon (2019-2044) is applied, which was chosen after a review of both the EU Guide[26] (15-25 years for energy sector) and the licence that the Greek Government issued in West Katakolon in November 2016 (25 years).

The impacts assessed were chosen due to their materiality to the Greek economy. Notably the assessment does not account for an exhaustive set of negative impacts (e.g. loss of value to coastal real estate, loss of biodiversity). The modelled impacts are:

- Clean-up impact (direct costs)
- Tourism impact (loss of GVA)
- Fishing impact (loss of GVA)
- Carbon impact (cost of emissions)

The clean-up impact represents the direct expenditure associated with clean-up activities due to spills. The tourism and fishing impact represent a loss of gross value added (GVA) through reduced expenditure. The potential loss of investment, in particular for the tourism sector, is not considered. The impact to the tourism industry also only considers inbound tourism expenditure; while each region may lose both inbound and domestic tourism in the event of an oil spill, it is assumed that the impact to domestic tourism will not translate to a net impact at the national level due to the displacement of domestic tourists to other regions. The carbon impact refers to the carbon emissions associated with extraction activities, and not emissions associated with the consumption of the produced oil and gas. Other potential impacts, notably environmental impacts, are not quantified within the model, but are discussed qualitatively in **Annex A**.

It is important to note that although the scope of the assessment is to focus on economic impacts, the omission of environmental impacts implies an underestimation of the negative impacts of hydrocarbon exploitation. This is especially the case as the "risks associated with the loss of biodiversity are not only ecological, moral and socio-cultural, they are also economic"[27].

The marine environment provides a variety of services contributing to human well-being and economic activities – so-called ecosystem services. The provision of food resources and the provision of "amenities and recreational supports, which encourage various economic activities to set up on the coast or at sea"[28] are examples of such ecosystem services. In the Mediterranean, amenities provided include the attractive

[26] European Commission (2008). Guide to cost-benefit analysis of investment projects. The EU.
[27] Mangos, A., Bassino, J-P. and D. Sauzade. (2010). The economic value of sustainable benefits rendered by the Mediterranean marine ecosystems. Valbonne: Plan Bleu, p.9
[28] Ibid., p. 32

landscape, climate and clear waters. They are important drivers for the development of hotels and restaurants and coastal real estate.

While the assessment at least partially accounts for these ecosystem services by looking at the impacts on the tourism and fishing industry, some potential negative impacts of hydrocarbon exploitation related to the aforementioned ecosystem services are not accounted for due to lack of information in existing literature. Impacts on the coastal real estate sector, for instance, are not covered in the assessment but could be investigated in future research by using hedonic pricing techniques. Other ecosystem services are not accounted for at all, which heightens the extent of underestimation of the negative impacts of hydrocarbon exploitation.

Non-assessed impacts on ecosystem services include, amongst others, the provision of climate regulation through carbon sequestration and the provision of erosion protection, which “ensures the durability of infrastructure and investments on a threatened coastline by contributing to its stability”[29]. The relevance of this ecosystem service is heightened by the fact that 28.6% of the Greek coastline is threatened by erosion. Apart from protecting infrastructure and investments, this ecosystem service also limits the amount of public funds necessary for financing man-made coastal erosion prevention measures. The overall benefits delivered to Greece as a result of ecosystem services have been estimated to amount to more than 3 billion euros in 2005, thereby highlighting the large scale of potential additional losses resulting from oil and gas extraction. [30] More information on ecosystem services can be found in **Annex A**.

Having identified the impacts to be assessed in the model, a number of variables had to be considered to assess their monetary value including the level of reserves and extraction rate, and in particular the risk of various sizes of spill. This variable is highly context dependent, and based on factors such as location, timing and receptors, and so was estimated using assumptions based on evidence from previous spills.

Based on estimates of these variables, the next step is to analysis the impacts over the assessment period. Following standard appraisal practice, impacts occurring in future time periods are discounted at a rate of 4%, based on guidance set out in the EU Guide to cost-benefits analysis of investment projects.

A final fundamental aspect of the assessment is sensitivity testing to determine how various variables affect the overall results of the assessment. In the development of the impact model, ranges of values for each parameter of the model have been applied (e.g. low, medium, high), to develop different ‘pathways’ from which the different scenarios draw to test the sensitivity of the results to an indicative selection of feasible future value streams[31].

2.2 Literature review and modelling of impacts

The review process started with an initial screening of literature recommended by WWF Greece, which included documents on planned and existing hydrocarbon exploitation in Greece as well as material on oil spill occurrence and impact analyses of historical oil spills in Europe, North America and the Middle East. This provided useful context on existing and planned extraction sites in Greece including information on the physical and environmental characteristics of the target areas, laws and regulations relevant to hydrocarbon exploitation in Greece, basic fiscal terms, royalties, fees and bonuses, and the expected

[29] *Ibid., p.40*
[30] *Ibid.*
[31] *See Annex B*

duration of exploration and exploitation phases. Additional literature and datasets were also collected and consulted to inform the study.

The initial screening process aimed at developing an understanding of the available data and its applicability and appropriateness for the model, focusing on extracting information on:

- The general parameters related to the assessment of costs including the estimated level of reserves and rate of extraction;
- The parameters directly related to the potential costs, including the risk and volume of various levels of spills;
- Data for modelling of the potential costs including clean-up costs, losses to the tourism and fishing industries, and the cost associated with carbon emissions from extraction activities; and
- Additional information on the environmental impact, such as total damage costs according to historic case studies, factors determining the extent of environmental damage such as the resilience of the environment, and the efficiency of clean-up activities and the length of recovery periods.

General findings from the literature review applicable to modelling the impacts (i.e. costs) of hydrocarbon exploitation on Greece are outlined here, with specific findings on the likelihood of an oil spill in Greece, the environmental and economic consequences of an oil spill, and Greece's vulnerability to an oil spill covered in greater detail in **Annex A**.

In general, costs arise from three sources:

- Negative impacts of operational (minor) spills;
- Negative impacts of operational emissions; and,
- Negative impacts of major spills.

Minor spills which may occur semi-regularly as a matter of operations will incur a clean-up cost and can have varying degrees of impact on the tourism and fishing industries, including through cumulative effects over time. The carbon impact associated with oil and gas extraction also occurs as a result of operational activities. However, the more unpredictable major spills that may occur as a result of hydrocarbon exploitation can have a significant one-off economic impact through clean-up costs, and losses to the tourism and fishing industries, along with additional environmental consequences, as discussed in brief below (for a more in-depth discussion on impacts, see **Annex A**).

2.2.1 Review of the risk of oil spills

The studies illustrate that the extent and nature of oil spills vary significantly depending on the affected infrastructure (e.g. pipelines, platforms and cargo vessels), and the reasons for the oil spill (e.g. grounding or collision with respect to cargo vessels[32], and blowout, explosion and structural failure with respect to platforms[33]). With respect to the likelihood of an oil spill, global historical trends in the occurrence of oil spill

[32] *Nyman, T. (2010). Evaluation of methods to estimate the consequence costs of an oil spill, produced as part of the SKEMA consolidation studies on 'Methods for assessing safety and security performance'.*

[33] *European Parliament. (2013). The impact of oil and gas drilling accidents on EU fisheries. Brussels: Aberdeen Institute for Coastal Science and Management.*

accidents[34] [35] as well as trends in Europe[36] are described in the literature. A statistical analysis of incidents having caused or having had a potential of causing oil spills specific to the Mediterranean Sea drawing on the Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC) alerts and accident database is also available.[37]

This is complemented by information on the level of development of oil extraction activities in different European waters including the Mediterranean Sea and regional characteristics posing particular challenges to oil extraction in this area[38], thereby allowing for an understanding of the risk in the Mediterranean Sea in comparison to other areas. In addition, oil spill occurrence rate estimates for the development and exploration stage for activities in the United States Outer Continental Shelf have also been found. Specific rates, which are provided on a basis of billion barrels of oil handled, are available for platforms, pipelines and tankers.[39] Annual probabilities of at least one blowout as a result of offshore oil operations in Europe, from exploration and development drilling and oil extraction, were also reviewed.[40]

2.2.2 Review of potential impacts of oil spills

Regarding the consequences of an oil spill, impact analyses of historic oil spills in Europe provide estimates of total damage costs, including case-specific clean-up cost estimates, monetary estimates of the impacts on the seafood and tourism industry, losses related to the loss of non-commercial species and natural heritage as well as recreation losses. The consulted studies relate to various past incidents, including:

- The *Amoco Cadiz* oil spill – a tanker incident near the coast of Brittany (France) in 1978[41];
- The *Exxon Valdez* oil spill – a tanker incident near the coast of Alaska (United States) in 1989[42];
- The *Erika* oil spill – a tanker incident near the French coast in 1999[43];
- The *Prestige* oil spill – a tanker incident near the coast of Galicia (Spain) in 2002[44] [45] [46];
- The El-Jiyeh oil spill in Lebanon in 2006 following an air strike on oil storage tanks [47] [48]; and

[34] *Ibid.*
[35] *Kontovas, C.A., Psaraftis, H.N. and N.P. Ventikos. (2010). An empirical analysis of IOPCF oil spill cost data. Marine Pollution Bulletin, 60, 1455-1466. doi: 10.1016/j.marpolbul.2010.05.010*
[36] *European Parliament. (2013). The impact of oil and gas drilling accidents on EU fisheries. Brussels: Aberdeen Institute for Coastal Science and Management.*
[37] *International Maritime Organization. (2011). Statistical analysis: Alerts and accidents database, Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea.*
[38] *European Parliament. (2013). The impact of oil and gas drilling accidents on EU fisheries. Brussels: Aberdeen Institute for Coastal Science and Management.*
[39] *Bureau of Ocean Energy Management & Bureau of Safety and Environmental Enforcement. (2016). 2016 Update of occurrence rates for offshore oil spills. Arlington: ABS Consulting Inc.*
[40] *European Commission. (2011). Impact assessment – Annex I accompanying the document 'Proposal for a regulation of the European Parliament and of the Council on safety of offshore oil and gas prospection, exploration and production activities.*
[41] *Grigalunas, T.A., Anderson, R.C., Brown, G.M., Congar, R. Meade, N.F. and P.E. Sorensen. (1986). Estimating the cost of oil spills: Lessons from the Amoco Cadiz incident. Marine Resource Economics, 2(3), 239-262. doi: 10.1086/mre.2.3.42628902*
[42] *Dorsett, M. (2010). Exxon Valdez oil spill continued effects on the Alaskan Economy, Colonial Academic Alliance Undergraduate Research Journal, 1, Article 7.*
[43] *Bonnieux, F. and P. Rainelli. (2002). Evaluation des dommages des marées noires: un-187.e illustration à partir du cas de l'Erika et des pertes d'agrément des résidents, Économie et statistique, 357-358, 173*
[44] *Garza, M.D., Prada, A., Varela, M. and M.X. Vazquez Rodriguez. (2009). Indirect assessment of economic damages from the Prestige oil spill: consequences for liability and risk prevention. Disasters, 33(1), 95-109. doi: 10.1111/j.0361-3666.2008.01064.x*
[45] *Loureiro, M.L., Ribas, A., López, E. and E. Ojea. (2006). Estimated costs and admissible claims linked to the Prestige oil spill. Ecological Economics, 59, 48-63. doi: 10.1016 /j.ecolecon.2005. 10.001*
[46] *Domínguez Álvarez, R. and M. L. Loureiro. (2013). Environmental accidents and stigmatized fish prices: Evidence from the prestige oil spill in Galicia. Economía Agraria y Recursos Naturales, 13 (2), 103-126.*
[47] *UNDP Lebanon. (2014). Report on the measurement & quantification of the environmental damage of the oil spill on Lebanon.*
[48] *World Bank. (2007). Republic of Lebanon: Economic assessment of environmental degradation due to July 2006 hostilities.*

- The *Deepwater Horizon* oil spill in the Gulf of Mexico in 2010[49] [50] [51] [52].

There are numerous complex factors which determine the impact of an oil spill. This includes both technical factors such as the type of oil and its toxicity and viscosity characteristics, the amount and rate of spillage and the clean-up effectiveness, and also prevailing local conditions including physical and biological characteristics and weather conditions which also contribute to the impact of oil spills[53] [54]. The complex interaction between various factors in fact "make[s] cost predictions based on simple parameters very unreliable"[55]. Adding to this difficulty is that the cost of oil spills is also influenced by economic characteristics of the oil spill location[56] and whether "environmentally or economically sensitive areas, fishing zones or areas with other maritime activities" [57] are affected.

Consulted studies also point to various other factors affecting the cost of an oil spill, such as the size of the spill, proximity to shore, type of oil, characteristics of the oil spill location and weather conditions[58], thereby illustrating the complexity of predicting the monetary value of damages caused. Methods and data to estimate the costs of an oil spill, such as unit spill cost estimates resulting from regression analyses of historical oil spill clean-up and total cost data, are nevertheless outlined in these studies. Apart from per-unit spill costs estimates resulting from regression analysis of tanker incidents [59] [60], per-unit clean-up costs for different global regions and European countries[61] [62] have also been retrieved.

The costs of a potential oil spill are thus highly dependent on the future economic development of the Greek industries likely to be affected by an oil spill (e.g. the tourism and fishing industry), which can be affected by a variety of additional factors such as economic stagnation in tourists' countries of origin reducing the ability of affording vacations abroad, and safety concerns in other popular tourism destinations. One study specifically attempts to analyse the potential impacts on island tourism destinations given their specific vulnerabilities.[63]

2.2.3 Review of additional parameters

In addition to the uncertainty related to modelling the costs of hydrocarbon exploitation in terms of damages caused by oil spills, the valuation of the impacts of hydrocarbon exploitation is also subject to a significant amount of uncertainty, including fluctuating oil prices which are sensitive to a variety of

[49] US Department of the Interior. (2016). An Analysis of the Impacts of the Deepwater Horizon Oil Spill on the Gulf of Mexico Seafood Industry. New Orleans: The Vertex Companies.
[50] Louisiana Office of Tourism. (2011). The impact of the BP oil spill on visitor spending in Louisiana: Revised estimates based on data through 2010 Q4. Oxford/Philadelphia/New York/London/Singapore: Tourism Economics.
[51] Greater New Orleans, inc. (2010). A study of the economic impact of the Deepwater Horizon oil spill. New Orleans: IEM.
[52] US Travel Association. (n.a.). Potential impact of the Gulf oil spill on tourism. Oxford: Oxford Economics.
[53] Nyman, T. (2010). Evaluation of methods to estimate the consequence costs of an oil spill, produced as part of the SKEMA consolidation studies on 'Methods for assessing safety and security performance'.
[54] European Commission. (2011). Impact assessment – Annex I accompanying the document 'Proposal for a regulation of the European Parliament and of the Council on safety of offshore oil and gas prospection, exploration and production activities.
[55] Nyman, T. (2010). Evaluation of methods to estimate the consequence costs of an oil spill, produced as part of the SKEMA consolidation studies on 'Methods for assessing safety and security performance', p.6.
[56] Ibid.
[57] European Commission. (2011). Impact assessment – Annex I accompanying the document 'Proposal for a regulation of the European Parliament and of the Council on safety of offshore oil and gas prospection, exploration and production activities, p.5
[58] Nyman, T. (2010). Evaluation of methods to estimate the consequence costs of an oil spill, produced as part of the SKEMA consolidation studies on 'Methods for assessing safety and security performance'.
[59] Ibid.
[60] Kontovas, C.A., Psaraftis, H.N. and N.P. Ventikos. (2010). An empirical analysis of IOPCF oil spill cost data. Marine Pollution Bulletin, 60, 1455-1466. doi: 10.1016/j.marpolbul.2010.05.010
[61] Nyman, T. (2010). Evaluation of methods to estimate the consequence costs of an oil spill, produced as part of the SKEMA consolidation studies on 'Methods for assessing safety and security performance'.
[62] European Commission. (2011). Impact assessment – Annex I accompanying the document 'Proposal for a regulation of the European Parliament and of the Council on safety of offshore oil and gas prospection, exploration and production activities.
[63] Álvarez Waló, N. (2016). Economic impacts of oil spills in island tourism destination. An application to the Canary Islands, Dissertation submitted to Universidad de La Laguna.

developments. Production shortages caused by major accidents elsewhere are one example of circumstances that can have profound economic implications for oil prices and ultimately even the prices of many goods and services using oil as a raw material. [64] Political instability in other oil-producing regions and changes in the demand of oil caused by technological and political development based on the desire to reduce the use of fossil fuels are further factors with a potential to affect the extent of impacts of hydrocarbon exploitation.

With respect to impacts on public perception, information on effects of an oil spill on the overall perception of the affected region, as well as tourism and seafood brands, is available for Louisiana in relation to the *Deepwater Horizon* oil spill. In addition, a study on the *Prestige* oil spill analyses the stigma effect that media publications relating to the oil spill had on fish prices. Information on the length of the environmental impacts of the respective oil spill are also available in some of the studies as is information on the ability of clean-up activities to limit the economic impacts of an oil spill through creating employment for affected fishers and the wider population.

While information on the effects of oil spills was abundant in the literature and included information from countries with similar geographic characteristics, e.g. Lebanon and Spain, information on the size and relative importance of the Greek industries to be affected in the case of an oil spill was scarce. This gap was filled by consulting official sources and statistics websites providing tourism sector statistics including visitor numbers, visitor expenditure, employment, revenue and tourism contributions to Gross Domestic Product (GDP), and fishing industry statistics at the national and regional levels. Additional studies on topics such as the regional dependency of European Union countries on fisheries[65] and the value of ecosystem services delivered by the Mediterranean marine ecosystems and its relative importance for Greece[66] were also consulted.

2.2.4 Modelling the impacts of hydrocarbon exploitation

To help manage the large amount of available information and facilitate the production of the model, parameter tables were used to extract quantitative and qualitative information relating to twelve specific parameters of the model in a consistent way. In practice, this involved extracting information on each of the variables contained in the formula to be used in the model. Parameters, for which information was extracted in this way, are (i) the level of reserves, (ii) the extraction rate, (iii) the oil spill risk, (iv) the cost of clean-up activities, (v) the impact of an oil spill on the tourism industry, (vi) the impact of an oil spill on the fishing industry, and (vii) the carbon impact of extraction activities.

Where data was not available, the modelling relied on assumptions to estimate impact. The data and assumptions for each parameter were used to calculate a series of ‘pathways’ (i.e. future impact value streams), to act as sensitivity ranges in order to test the sensitivity of the model to the various data and assumptions used. The model (Excel workbook) is structured so that all data, assumptions, and subsequent calculations are referenced and transparent; **Table 2.1** briefly describes each parameter with an outline of the formula applied in its calculation, the adopted data and assumptions employed, and the various pathways developed as sensitivity ranges.

[64] *Ibid.*
[65] *European Parliament Committee on Fisheries. (2007). Regional dependency of fisheries. Brussels: Framian bv and Poseidon Ltd.*
[66] *Mangos, A., Bassino, J-P. and D. Sauzade. (2010). The economic value of sustainable benefits rendered by the Mediterranean marine ecosystems. Valbonne: Plan Bleu.*

Table 2.1: Parameter calculation summaries

Parameter	Description	Formula	Data used	Assumptions	Pathways (i.e. sensitivity ranges)
Level of reserves	Oil reserves are an estimate of the amount of crude oil available at each site.	Estimated level of reserves per site in million barrels of oil, with a constant level of extraction over the assessment period to depletion.	1. Low and High estimation of reserves provided by WWF Greece.	1. Assumed a medium estimation of reserves; 2. Assumed Constant level of extractions over assessment period to depletion; 3. Concession estimates are split between regions where they overlap.	1. Lower quantity of reserves projected; 2. Middle quantity of reserves projected; 3. Higher quantity of reserves projected.
Rate of extraction	The level of extraction is an estimate of the amount of crude oil to be extracted at each site per year.	Estimated level of reserves per site in million barrels of oil with a constant level of extraction over assessment period to depletion.	1. Low and High estimation of reserves provided by WWF Greece.	1. Assumed a medium estimation of reserves; 2. Assumed Constant level of extractions over assessment period to depletion.	1. Lower rate of extraction based on lower value of reserves projected; 2. Middle rate of extraction based on medium value of reserves projected; 3. Higher rate of extraction based on higher value of reserves projected.
Spill risk and volume	The risk of spill estimates the probability of oil spill per barrel produced/transported.	Expected spill = Expected number of 'Small' oil spills* volume + expected number of 'Medium' oil spills * volume + expected number of 'Large' oil spills * volume	1.The data for risk and volume of small, medium large spills is estimated by The Bureau of Safety and Environmental Enforcement (BSEE).	1. Assumed 10,000 barrels for a 'major spill'; 2. The major spill is modelled as occurring in year 12, the mid-point of the assessment, for the purposes of discounting; 3. Assumed 'high risk' equates to proportional uplift of 1.5; 4. Assumed that spill is proportionally distributed across regions.	1. Low extraction, average risk; 2. Middle extraction, average risk; 3. High extraction, average risk; 4. Middle extraction, high risk – high risk equals 50% increase in spills; 5. Pathway 2, but with a major spill in year 12 (mid-year of the assessment)

Clean-up cost	This parameter provides an estimation of the costs incurred for clean-up activities required after an oil spill.	Clean-up impact = Average per unit marine oil spill clean-up cost in Greece * Weight of oil spilled	1. European Commission data on the average per unit marine oil spill clean-up cost in Greece.	1. No assumptions needed.	1. Low extraction, average risk; 2. Middle extraction, average risk; 3. High extraction, average risk; 4. Middle extraction high risk – high risk equals 50% increase in spills; 5. Major spill in 12 years (based on Pathway 2)
Tourism impact	This parameter estimates the possible effects on the tourism industry.	Tourism impact = Risk of spill * estimated % impact * value of tourism sector GVA by region * tourism sector growth rate * Economic multiplier * impact to tax revenues from sector	1.Growth of tourism estimate from World Travel & Tourism Council; 2. Economic multiplier from SETE; 3. Travel receipts by region statistics from Bank of Greece; 4. Oil spill impacts on tourism revenue from Oxford Economics estimates. 5. GVA/turnover estimate from ELSTAT data; 6. Tax contribution estimate from Hellenic Statistics.	1. Assumed cumulative impact from medium spills (conservative impact) - i.e. medium spill is 5% impact of major spill impact; 2. Assumed cumulative impact from medium spills (conservative impact) - i.e. medium spill is 25% impact of major spill impact; 3. Assumed that relatively routine small spills do not have an impact on tourism; 4. Assumed no macro impact from loss of domestic tourism (due to substitution).	1. Medium spills only; 2. Medium and large spills; 3. Medium and large spills + major spill (low); 4. Medium and large spills + major spill (high); 5. Minor spills + major spill (Lingering impact)

Fishing impact	This parameter estimates the possible effects on the fishing industry.	Fishing impact = Risk of spill * estimated % impact * value of sector GVA by region * fishing sector growth rate * Economic multiplier * impact to tax revenues from sector	1.Fisheries sector by region data from the European Parliament; 2.Impact from reputational damage data estimates based on a historic evidence and European Parliament data; 3. Economic multipliers from ELSTAT data; 4. GVA/turnover estimate from ELSTAT data; 5. Tax contribution estimate from Hellenic Statistics.	1. Assumed fishing sector growth rate of 1%.	1. Minor spills; 2. Minor spills + major spill (Low); 3. Minor spills + major spill (High); 4. Minor spills + major spill (Lingering impact)
Carbon impact	A carbon impact is a cost applied to carbon pollution generated through the extraction of oil and gas	Carbon impact = CO_2 per tonne of oil extracted * Carbon price	1.Tonnes of CO_2 per thousand tonnes of production from International association of Oil & Gas producers; 2.Price of carbon emissions from EEX group and Synapse Energy Economics.	1. Assumed price of carbon emission increase by 50% by 2030 based on OECD estimate leads to 4.5% increase as a sensitivity.	1. Carbon follows actual price 2. Carbon price follow OECD prediction 3. Carbon price follow Synapse prediction

3. Scenarios

This section sets out details of the four scenarios assessed within this study. Section 3.1 explains why scenario analysis was the best approach for this study, followed by Sections 3.2-3.5 which provides a description of each of the four scenarios assessed respectively.

3.1 Scenario development

Scenario analysis was deemed the optimal approach to assessing the potential impacts of implications of hydrocarbon exploitation Greece, in light of all the significant real-world uncertainties, such as how big are the oil and reserves at each concession site, what might the demand and price of oil and gas be over 25 years, what if there was a major oil spill during this period, and could oil spills affect the marine environment as well as tourist and fishing industry.

It enables the assessment of a range of plausible outcomes through four different scenarios without trying to predict the likelihood/plausibility of each scenario:

- **Scenario 1** is central estimate scenario in terms of assuming that the benefits generated by oil extraction follow best available forecasts for the price of oil as well as assuming the available information on predicted levels of reserve are accurate. It also conservatively assumes that over a 25-year period only small, medium and largescale spills will occur (i.e. there is no major oil spill) following best available information on the probability of different sizes and types of oil spills.
- **Scenario 2** is a best-case scenario in terms of the economic benefits generated by oil extraction due to higher than forecasted oil and gas prices, larger reserves levels than predicted and increased global demand for Greek oil. Like Scenario 1, this scenario assumes that only small, medium and large-scale spills occur over a 25-year period (i.e. there is no major oil spill).
- **Scenario 3** is a more pessimistic economic scenario than Scenario 1 and Scenario 2, where it is assumed that the actual level of oil reserves in Greece is lower than the level initially predicted, and lower global prices for oil and gas prices than forecasted. This scenario still assumes only small, medium and large -scale spills occur over a 25-year period (i.e. there is no major oil spill).
- **Scenario 4** is similar to Scenario 1, in that it uses the same 'central' estimates concerning economic benefits. The main variation is an assumption that there is a single (over a 25-year period) major oil spill affecting the Greek coast line. This major oil spill will in turn have a large negative impact on the marine environment, tourism, and the fishing industry. Whilst a major oil spill is assumed, the volume of oil spilt is on the smaller scale compared to other historical examples of major oil spills.

The scenarios were agreed with WWF Greece in advance of modelling them, based on the rationale that any of the four scenarios could feasibly occur in the future. It further underlies the value of using a scenario analysis rather than produce a single expected outcome with little degree of confidence being possible.

The scenarios are not meant to be predictions of specific events, but to test how a range of variables might impact the overall analysis (e.g. does it matter if the price of oil is uncertain, that the level of reserves is uncertain or if a major oil spill occurs).

The four scenarios chosen for the analysis were formulated using available literature published by the European Commission, WWF Greece, the German Federal Foreign Office and some collaborating organisations, the Organisation for Economic Co-operation and Development (OECD) and the United Nations (UN) which provided for example forecasted scenarios for the Greek economy.

Further details on each of the scenarios can be found below in Sections 4.2 through to 4.5.

3.2 Scenario 1 – Central outlook

This scenario assumes a positive economic context in Greece, with relatively high economic benefits from hydrocarbon exploitation, and Greece sustaining positive economic development leading to higher employment and increased investment activities which further stimulates the Greek economy.

The ongoing recovery from the financial crisis in Greece, which led to the implementation of extensive austerity measures and the provision of an assistance programme under the European Stability Mechanism (ESM), is difficult to predict given its interrelatedness with political and social developments at national and European level, such as progress towards European integration which is under threat in a time of increased Europe-wide support for populist parties.[67] Nevertheless, recent developments have increased the probability of a positive economic outlook. The OECD noted in May 2018, that "economic growth is the strongest since the onset of the economic crisis"[68] and that GDP is predicted to increase by 2.3% in 2019 driven mainly by exports "benefitting from rising external demand and improved competitiveness"[67].

The strength of the economic development in Greece is also predicted to have a positive effect on the seafood and tourism industries stimulated by increases in disposable income in the Greek population leading to increased domestic seafood consumption and recreational trips. Under this scenario it is assumed there will be significant economic benefits generated by oil extraction with no negative external shocks on the oil price, and current predictions of the level of reserves available in Greece (as provided by WWF Greece) prove to be accurate.

As noted in Section 1, Greece is subject to a higher risk of damage from an oil spill relative to other European countries. Under this scenario it is assumed that Greece does not experience any major oil spills, which generally "have the largest short-term impact on the environment and on fisheries and aquaculture"[69], although it is still assumed to experience more regular small, medium and large-scale spills. The low total volume of oil spilled determines the economic costs of clean up, the total impact on the environment, the tourism industry, and the seafood industry, and subsequent damage costs. However, it should be noted that despite relatively minor short-term impacts, the potential for long-term cumulative damage from small-scale accidents, on which reliable information is lacking[70], should not be ignored as "they have an important role in pollution, and their effect may be important in the long run". Whilst the clean costs per barrel of oil split is modelled, it was not possible to assess the cumulative impacts of these spills on the environment.

[67] *Federal Foreign Office, Friedrich Ebert Stiftung and European Academy Berlin. (2017). Greece and the EU in 2035: Scenario report on the first European Future Summit 2017 in the European Academy Berlin. Retrieved from: https://www.eab-berlin.eu/wp-content/uploads/EAB-Scenario-report-2_171219.pdf*
[68] *OECD. (2018). OECD Economic Outlook, Volume 2018, Issue 1. Paris: OECD Publishing. 1*
[69] *European Parliament. (2013). The impact of oil and gas drilling accidents on EU fisheries. Brussels: Aberdeen Institute for Coastal Science and Management, p.21*
[70] *Ibid.*

The parameters used to model scenario 1 are set out below in **Table 3.1**. As noted in Section 2, for each type of parameter (e.g. price of oil), a low, medium (central) or high estimate was derived using the readily available information gathered. For scenario 1, for most parameters, the medium (central) estimate was applied, reflecting the best estimate within the information gathered.

Table 3.1: Parameter pathway selection for Scenario 1

Parameter	Assumed pathway
Price of oil	Projected price (US Energy Information Administration)
Level of reserves	Medium estimate for level of reserves
Extraction cost	Central estimate for the cost of extraction
Employment impact	Based on employment coefficient for Norwegian oil and gas sector
Tax impact	Based on medium estimate of oil and gas extracted
Economic impact	Based on medium level of estimate of oil and gas extracted
Risk of spill	The average risk of spills based on a central estimate of oil and gas extracted
Clean-up impact	The average cost of cleaning up based on a central level of estimate of oil and gas extracted
Tourism impact	Impacts based on medium and large size spills only
Fishing impact	Impacts based on medium and large size spills only
Carbon impact	Carbon emissions price based on OECD annual price increase over time prediction

3.3 Scenario 2 – Positive outlook

This scenario assumes the same underlying economic context in Greece as Scenario 1, while also assuming a near best-case situation in terms of the economic benefits generated by hydrocarbon exploitation. In this scenario, a lack of reliable supply from other oil and gas producing regions leads to increased demand for oil and gas from relatively stable exporters such as Greece. This leads to higher (than forecasted) oil and gas prices, which has a positive impact on the benefits of hydrocarbon exploitation in Greece, including the number of jobs created and the amount of tax revenue generated.

As more oil is extracted in a shorter period of time relative to Scenario 1, due to the increase in demand and prospect of higher profits, the risk of an oil spill increases, which is dependent on the number of barrels handled[71]. While under this scenario, Greece is still assumed to not experience any major oil spills, the increased production ultimately results in more small-to-medium-scale oil spills and consequently there would be a higher negative impact on tourism and fishing industries relative to Scenario 1. Apart from increasing the risk of oil spills caused at oil extraction platforms, the risk of spills during transport also increases given increased traffic.

Transportation incidents, which have historically been responsible for the majority of spills in Europe[72], can also cause significant damage as illustrated by the Prestige oil spill which caused exceptional damage. These were estimated at approximately €2.3 billion, including cleaning and restoration costs, biodiversity damages, and losses incurred in the fishing and tourism industries[73]. The extent of the damage cost by the Prestige oil spill is an outlier however, as the “majority of recent [transport] accidents have had only moderate or minor environmental effects”[74]. The negative impact on the tourism industry from more small-

[71] *Bureau of Ocean Energy Management & Bureau of Safety and Environmental Enforcement. (2016). 2016 Update of occurrence rates for offshore oil spills. Arlington: ABS Consulting Inc.*
[72] *European Parliament. (2013). The impact of oil and gas drilling accidents on EU fisheries. Brussels: Aberdeen Institute for Coastal Science and Management.*
[73] *Garza, M.D., Prada, A., Varela, M. and M.X. Vazquez Rodriguez. (2009). Indirect assessment of economic damages from the Prestige oil spill: consequences for liability and risk prevention. Disasters, 33(1), 95-109. doi: 10.1111/j.0361-3666.2008.01064.x*
[74] *European Parliament. (2013). The impact of oil and gas drilling accidents on EU fisheries. Brussels: Aberdeen Institute for Coastal Science and Management, p.28*

to-medium scale spills in comparison to Scenario 1 is also assumed to be exacerbated by the impact the increase in oil transport has by negatively impacting the visitor experience due to increased visual nuisance and the disruption of popular cruise routes.

The parameters used to model scenario 2 are set out below in **Table 3.2**. As noted in Section 2, for each type of parameter (e.g. price of oil), a low, medium (central) or high estimate was derived using the readily available information gathered. For scenario 2, for economic parameters, the high estimate was applied, using the higher plausible estimates gathered from the available literature.

Table 3.2: Parameter pathway selection for Scenario 2

Parameter	Assumed pathway
Price of oil	10% higher than forecasted price
Level of reserves	High estimate for level of reserves
Extraction cost	Annual 1% decrease in the costs of extraction relative to the central estimate
Employment impact	Based on employment coefficient for Norwegian oil and gas sector
Tax impact	Based on high estimate of oil and gas extracted
Economic impact	Based on high estimate of oil and gas extracted
Risk of spill	The average risk of spills is based on the high estimate of oil and gas extracted
Clean-up impact	Based on high level of extraction and average risk of oil spills
Tourism impact	Impacts based on medium and large size spills only
Fishing impact	Impacts based on medium and large size spills only
Carbon impact	Carbon emissions price remains at current level

3.4 Scenario 3 – Negative outlook

This scenario models a situation whereby the expected benefits being generated by the hydrocarbon exploitation are less than forecasted (compared to scenario 1) by assuming declining oil prices due to reduced global demand for oil (e.g. because of the early adoption of electric vehicles, the increased use of renewable energy sources, and requirements to reduce oil consumption to meet global climate change targets).

This outlook reflects the *Green economy/ green growth world scenario* – a future scenario reflecting one of the "positions taken in the global sustainable development debate"[75] presented in a publication of the United Nations - which assumes a political and social environment focused on economic growth but also the achievement of selective environmental objectives[56]. The use of economic instruments such as the price mechanism and increased public investment in environmentally friendly technologies are seen as the preferred option for achieving these objectives. According to the *Climate change world scenario* mitigating and adapting to climate change might be one of the central environmental targets. The scenario suggests that public investment will result in the increased uptake of renewal energy sources and improvement in energy efficiency,[76] resulting in a reduction of demand for oil and thus a lower oil price trend assuming the global oil supply is stable.

Under scenario 3 it is also assumed that the forecasted oil reserves in Greece have been over-estimated during the exploration stage, modelled using a lower estimate for the size of reserves. The combination of lower prices and reserves, results in lower economic benefits from hydrocarbon exploitation, in terms of

[75] *Roehrl, R.A. (2012). Sustainable development scenarios for Rio+20 - A Component of the Sustainable Development in the 21st Century (SD21) project. New York: United Nations Department of Economic and Social Affairs, Division for Sustainable Development, p.144*
[76] *Ibid.*

tax revenues, job creation, and stimulation of the Greek economy, relative to the two previous scenarios (scenario 1 and 2).
The comparatively lower demand for oil and reduction in volumes extracted in Greece will (statistically) reduce the risk of an oil spill (which is linked to the volume of oil handled). As with the two previous scenarios, this scenario also assumes that Greece will not experience a major oil spill, but a limited number of small-to-medium scale spills.

The parameters used to model scenario 3 are set out below in **Table 3.3**. As noted in Section 2, for each type of parameter (e.g. price of oil), a low, medium (central) or high estimate was derived using the readily available information gathered. For scenario 3, for economic parameters, the low estimate was applied, using the lower plausible estimates gathered from the available literature.

Table 3.3: Parameter pathway selection for Scenario 3

Parameter	Assumed pathway
Price of oil	10% lower than forecasted price
Level of reserves	Low estimate for level of reserves
Extraction cost	High estimate for the cost of extraction
Employment impact	Based on employment coefficient for Norwegian oil and gas sector
Tax impact	Based on low level of oil and gas extracted
Economic impact	Based on low level of oil and gas extracted
Risk of spill	Based on low level of oil and gas extracted and average risk of spills
Clean-up impact	Based on low level of oil and gas extracted and average cost for spills
Tourism impact	Impacts based on medium and large size spills only
Fishing impact	Impacts based on medium and large size spills only
Carbon impact	Synapse Energy Economics prediction

3.5 Scenario 4 – Catastrophic oil spill

This scenario is assessed assuming the same economic context as Scenario 1 (i.e. a strong economy that has recovered well from the financial crisis). Economic development has a knock-on benefit to the tourist and seafood industry, thereby increasing the potential for higher damage costs in the case of a major oil spill.

In contrast to the other three scenarios, which all assumed that Greece would only experience small, medium and large-scale spills, this scenario assumes the occurrence of one major oil spill affecting a large part of the coastline of Greece resulting in significant environmental damage. A consequence of the larger spill volume and affected area, a higher impact (e.g. both cost and duration of impact) to the tourism and seafood industry as well as significant clean-up costs are assumed to incur.

The parameters used to model scenario 4 are set out below in **Table 3.4**. As noted in Section 2, for each type of parameter (e.g. price of oil), a low, medium (central) or high estimate was derived using the readily available information gathered. For scenario 4, for economic parameters, the central (medium) estimate was applied, using the best plausible estimates gathered from the available literature. The main variation is an assumption that there is a single (over a 25-year period) major oil spill affecting the Greek coast line. This major oil spill will in turn have a large negative impact on the marine environment, tourism, the fishing industry and general perception of Greece. Whilst a major oil spill is assumed, the volume of oil spilt is on the smaller scale compared to other historical examples of major oil spills.

Table 3.4: Parameter pathway selection for Scenario 4

Parameter	Assumed pathway
Price of oil	Projected price (US Energy Information Administration)
Level of reserves	Medium estimate for level of reserves
Extraction cost	Central estimate for the cost of extraction
Employment impact	Based on employment coefficient for Norwegian oil and gas sector
Tax impact	Based on medium estimate of oil and gas extracted
Economic impact	Based on medium level of estimate of oil and gas extracted
Risk of spill	Based on central estimate for the level of oil and gas extracted and assumption of a major spill
Clean-up impact	The average cost of cleaning up based on a central level of estimate of oil and gas extracted and the cost of cleaning up a major spill
Tourism impact	Impacts based on medium and large spills + major spill (High)
Fishing impact	Impacts based on medium and large spills + major spill (High)
Carbon impact	OECD annual price increase prediction

4. Headline costs

WWF requested eftec to present information on the costs of extraction as this information was of higher importance for the preparation of their campaign materials. Therefore Section 4 sets out the headline costs under Scenarios 1-4 as set out in Section 3[77]. A full cost-benefit analysis can be found in the supporting model provided to WWF Greece, as described in **Annex B**.

4.1 Scenario 1 results

Scenario 1 is a 'central' estimate scenario in terms of assuming that the benefits generated by oil extraction follow best available forecasts for the price of oil as well as assuming the available information on predicted levels of reserve are accurate. It therefore represents a scenario with moderate costs, and with the notable absence of a major spill. The total estimated cost associated with this scenario (based on the financial cost of clean-up, impact on the tourism and fishing industries, and price of carbon emissions associated with extraction) is €1.28 billion in present value[78] (the undiscounted value is €2.17 billion). The breakdown by type of impact can be found in **Table 4.1**, while the breakdown by region can be found in **Table 4.2**.

Table 4.1: Breakdown of costs by type of impact for Scenario 1

Impact	Estimated cost (25-year assessment, PV)	Per annum cost (average)
Clean-up	€23 million	€1 million
Tourism	€560 million	€22million
Fishing	€12 million	€1 million
Carbon	€679 million	€27 million
TOTAL	**€1,275 million**	**€50 million**

Table 4.2: Breakdown of costs by region for Scenario 1

Region	Estimated cost (25-year assessment, PV)	Per annum cost (average)
Eastern Macedonia and Thrace	€8 million	<€1 million
Crete	€304 million	€12 million
Epirus	€81 million	€3 million
Ioanian Islands	€735 million	€29 million
Peloponnese	€75 million	€3 million
Western Greece	€56 million	€2 million
Central Macedonia	€16 million	€1 million
TOTAL	**€1,275 million**	**€50 million**

The costs are largely being driven by the negative impacts on the tourism industry from medium-large oil spills and the cost of carbon emitted due to high CO_2 intensity of extracting oil and gas. The main regions affected are the Ioanian Islands and Crete as these are popular with tourists. Although no major spill is expected (or modelled), regular medium and large-scale spills are predicted to impact the tourism and fishing industries, while the carbon emissions associated with hydrocarbon exploitation are a significant source of greenhouse gases.

[77] *Note minor discrepancies in totals are due to rounding.*
[78] *Present value (PV) is based on 2017 prices using a 4% discount rate and 25-year period.*

4.2 Scenario 2 results

Scenario 2 is similar to Scenario 1 but takes a more optimistic view on the economic impact of hydrocarbon exploitation, and modelling fewer spills to occur (relative to Scenario 1) and using a lower unit cost of carbon emissions over time. Fewer spills reduces the total cost to the tourism industry and lower carbon prices reduce the costs of carbon emissions. The total estimated cost associated with this scenario (based on the financial cost of clean-up, impact on the tourism and fishing industries, and price of carbon emissions associated with extraction) is €882 million present value (the undiscounted value is €1.43 billion). The breakdown by type of impact can be found in **Table 4.3**, while the breakdown by region can be found in **Table 4.4**.

Table 4.3: Breakdown of costs by impact for Scenario 2

Impact	Estimated cost (25-year assessment, PV)	Per annum cost (average)
Clean-up	€27 million	€1 million
Tourism	€436 million	€18 million
Fishing	€12 million	€1 million
Carbon	€407 million	€16 million
TOTAL	**€882 million**	**€35 million**

Table 4.4: Breakdown of costs by region for Scenario 2

Region	Estimated cost (25-year assessment, PV)	Per annum cost (average)
Eastern Macedonia and Thrace	€5 million	<€1 million
Crete	€218 million	€9 million
Epirus	€51 million	€2 million
Ioanian Islands	€512 million	€21 million
Peloponnese	€48 million	€2 million
Western Greece	€36 million	€1 million
Central Macedonia	€11 million	<€1 million
TOTAL	**€882 million**	**€35 million**

As with Scenario 1, the costs are largely being driven by the negative impacts on the tourism industry and the cost of carbon emitted. The main regions affected are the Ioanian Islands and Crete as these are popular with tourists. Although no major spill is expected, medium and large-scale spills still are predicted to impact the tourism industry, while the carbon emissions associated with hydrocarbon exploitation are a significant source of greenhouse gases.

4.3 Scenario 3 results

Scenario 3 is similar to Scenario 1 but takes a more pessimistic view on the economic impact of hydrocarbon exploitation, assuming less benefits along with moderate costs from spills and a higher cost of carbon over time. The effect on the total costs is similar to that of Scenario 1. The total estimated cost associated with this scenario (based on the financial cost of clean-up, impact on the tourism and fishing industries, and price of carbon emissions associated with extraction) is €1.24 billion present value (the undiscounted value is €2.14 billion). The breakdown by type of impact can be found in **Table 4.5**, while the breakdown by region can be found in **Table 4.6**.

Table 4.5: Breakdown of costs by impact for Scenario 3

Impact	Estimated cost (25-year assessment, PV)	Per annum cost (average)
Clean-up	€20 million	<€1 million
Tourism	€560 million	€22 million
Fishing	€12 million	<€1 million
Carbon	€651 million	€26 million
TOTAL	**€1243 million**	**€50 million**

Table 4.6: Breakdown of costs by region for Scenario 3

Region	Estimated cost (25-year assessment, PV)	Per annum cost (average)
Eastern Macedonia and Thrace	€8 million	<€1 million
Crete	€299 million	€12 million
Epirus	€77 million	€3 million
Ioanian Islands	€717 million	€29 million
Peloponnese	€72 million	€3 million
Western Greece	€54 million	€2 million
Central Macedonia	€15 million	€1 million
TOTAL	**€1243 million**	**€50 million**

As with Scenario 1 and Scenario 2, the costs are largely being driven by the negative impacts on the tourism industry and the cost of carbon emitted. The main regions affected are the Ioanian Islands and Crete as these are popular with tourists. Although no major spill is expected, more regular medium and large- scale spills still may impact the tourism and fishing industries, while the carbon emissions associated with hydrocarbon exploitation are a significant source of greenhouse gases.

4.4 Scenario 4 results

Scenario 4 models the effect of a major spill on the economic impact of hydrocarbon exploitation. Other than the inclusion of a major incident in the mid-point of the 25-year assessment it is similarly modelled to Scenario 1 in terms of economic impacts. This major oil spill incident would significantly impact the tourism and fishing industries. The total estimated cost associated with this scenario (based on the financial cost of clean-up, impact on the tourism and fishing industries, and price of carbon emissions associated with extraction) is €5.94 billion present value (the undiscounted value is €9.80 billion). The breakdown by type of impact can be found in **Table 4.7**, while the breakdown by region can be found in **Table 4.8**.

Table 4.7: Breakdown of costs by impact for Scenario 4

Impact	Estimated cost (25-year assessment, PV)	Per annum cost (average)
Clean-up	€34 million	€1 million
Tourism	€5,047 million	€202 million
Fishing	€183 million	€7 million
Carbon	€679 million	€27 million
TOTAL	**€5943 million**	**€238 million**

Table 4.8: Breakdown of costs by region for Scenario 4

Region	Estimated cost (25-year assessment, PV)	Per annum cost (average)
Eastern Macedonia and Thrace	€190 million	€8 million
Crete	€2,161 million	€86 million
Epirus	€217 million	€9 million
Ioanian Islands	€1,783 million	€71 million
Peloponnese	€283 million	€11 million
Western Greece	€161 million	€7 million
Central Macedonia	€1,147 million	€46 million
TOTAL	**€5943 million**	**€238 million**

As would be expected, the costs are significantly greater under this scenario. In particular the impact on the tourism industry in this scenario is several times larger than in scenarios with the absence of a major spill incident, costing the Greek economy several billion euro over the 25-year assessment period. The main regions affected are the Ioanian Islands and Crete as these are popular tourist regions.

The one-off cost of a major spill is estimated at €7.74 billion. This is larger than the estimated cost for the 25-year assessment period as the impact is modelled as occurring in the mid-point of the assessment period and are discounted accordingly. This value represents approximately 4% of Greece's current GDP.

5. Regional results

This section presents the results for each region broken down by the impact categories (i.e. clean-up impact, tourism impact, fishing impact, and carbon impact), for each of the modelled scenarios. The clean-up impact represents a direct cost, while costs via impacts to the tourism and fishing sectors are through losses to GVA, and carbon impact costs are those associated with the emissions created through extraction activities.

Within the tourism and fishing sector cost estimate totals, multipliers have been used to factor the wider indirect and tax (fiscal) impacts in to the overall values. The estimated tax impacts from a loss of GVA from the tourism and fishing sectors over the assessment period are presented for each region. The estimated employment impact from a loss of GVA from the tourism and fishing sectors are also presented[79] for each region; however, it should be noted that these are presented as annual Full Time Equivalent (FTE)[80] values. In particular, note that under Scenario 4, the value in brackets is the one-off FTE impact following a major spill, rather than an annual average, and represents the scale of employment potentially at risk in the short to medium term should such an event occur.

As discussed previously, some regions are disproportionally affected such as where the tourism industry, or to a smaller degree the fishing industry, make a relatively large contribution to the regional economy. For example, tourism represents more than 70% of regional GDP in the Ionian Islands, and 47.4% of GDP in Crete[81], while similarly, the fishing industry contributed €230.2 million and €109.0 million to Central Macedonia and Peloponnese respectively in 2005[82]. Subsequently, the scale of the impact on these industries is greater in these regions. Other regions, such as Eastern Macedonia and Thrace, and Central Macedonia, are relatively less impacted, except in the case of a major spill incident (Scenario 4), due to both the structure of their economies and the estimated level of risk that they are exposed to from extraction activities.

5.1 Eastern Macedonia and Thrace

Table 5.1 presents the results broken down by each impact under each scenario for Eastern Macedonia and Thrace, while

Table 5.2 breaks out the regional tax (fiscal) impact and employment (annual FTE) impact from a loss of GVA from the tourism and fishing sectors.

Table 5.1: Regional impact for Eastern Macedonia and Thrace

Impact	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Clean-up	€0.2 million	€0.3 million	€0.1 million	€0.3 million
Tourism	€1 million	€0.8 million	€1 million	€163.4 million
Fishing	€0.1 million	€0.1 million	€0.1 million	€19.3 million
Carbon	€7 million	€4.1 million	€6.7 million	€7 million
Total	**€8.4 million**	**€5.4 million**	**€8.0 million**	**€190 million**

[79] *Employment impact as presented here is estimated as the total loss of GVA for each sector, divided by the GVA per FTE for that sector.*
[80] *An FTE is the equivalent number of hours to a full-time position, rather than an actual employment position. However, one FTE could be spread across multiple employees, so that the number of people impacted by the loss of one FTE may be greater than one.*
[81] *SETE Intelligence, 2018. Retrieved from: https://sete.gr/media/10888/2018_symvolhtourismou-2017.pdf*
[82] *European Parliament, 2007. Regional Dependency on Fish. Policy Department – Structural and Cohesion Policies*

Table 5.2: Tax and employment cost breakdown for Eastern Macedonia and Thrace

Impact	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Tourism – Tax	€0.2 million	€0.1 million	€0.2 million	€30.5 million
Fishing - Tax	<€0.1 million	<€0.1 million	<€0.1 million	€3.6 million
Tourism - Employment	2	1	2	[3,856]
Fishing - Employment	<1	<1	<1	[923]

5.2 Crete

Table 5.3 presents the results broken down by each impact under each scenario for Crete, while **Table 5.4** breaks out the regional tax (fiscal) impact and employment (annual FTE) impact from a loss of GVA from the tourism and fishing sectors.

Table 5.3: Regional impact for Crete

Impact	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Clean-up	€3.8 million	€3.8 million	€3.8 million	€5.6 million
Tourism	€187.4 million	€146.0 million	€187.4 million	€2,030.6 million
Fishing	€1.3 million	€1.3 million	€1.3 million	€13.9 million
Carbon	€110.9 million	€66.4 million	€106.2 million	€110.9 million
Total	**€303.5 million**	**€217.5 million**	**€298.8 million**	**€2,161 million**

Table 5.4: Tax and employment cost breakdown for Crete

Impact	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Tourism – Tax	€35.0 million	€27.3 million	€35.0 million	€379.4 million
Fishing - Tax	€0.3 million	€0.3 million	€0.3 million	€2.6 million
Tourism - Employment	337	263	337	[44,874]
Fishing - Employment	3	4	3	[609]

5.3 Epirus

Table 5.5 presents the results broken down by each impact under each scenario for Epirus, while **Table 5.6** breaks out the regional tax (fiscal) impact and employment (annual FTE) impact from a loss of GVA from the tourism and fishing sectors.

Table 5.5: Regional impact for Epirus

Impact	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Clean-up	€2.4 million	€2.9 million	€1.9 million	€3.5 million
Tourism	€7.8 million	€6.1 million	€7.8 million	€132.4 million
Fishing	€0.7 million	€0.7 million	€0.7 million	€11.8 million
Carbon	€69.8 million	€41.7 million	€66.8 million	€69.8 million
Total	**€80.7 million**	**€51.5 million**	**€77.3 million**	**€217.5 million**

Table 5.6: Tax and employment cost breakdown for Epirus

Impact	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Tourism – Tax	€1.46 million	€1.1 million	€1.5 million	€24.7 million
Fishing - Tax	€0.1 million	€0.1 million	€0.1 million	€2.2 million
Tourism - Employment	14	11	14	[2,971]
Fishing - Employment	1	1	1	[533]

5.4 Ionian Islands

Table 5.7 presents the results broken down by each impact under each scenario for Ionian Islands, while **Table 5.8** breaks out the regional tax (fiscal) impact and employment (annual FTE) impact from a loss of GVA from the tourism and fishing sectors.

Table 5.7: Regional impact for Ionian Islands

Impact	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Clean-up	€12.8 million	€15.3 million	€10.2 million	€18.7 million
Tourism	€342.6 million	€266.9 million	€342.6 million	€1,364.4 million
Fishing	€7.3 million	€7.3 million	€7.3 million	€27.7 million
Carbon	€372.5 million	€222.9 million	€356.8 million	€372.5 million
Total	**€735.3 million**	**€512.5 million**	**€717 million**	**€1,783.5 million**

Table 5.8: Tax and employment cost breakdown for Ionian Islands

Impact	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Tourism – Tax	€64.0 million	€48.9 million	€64.0 million	€255.0 million
Fishing - Tax	€1.4 million	€1.4 million	€1.4 million	€5.2 million
Tourism - Employment	616	480	616	[24,844]
Fishing - Employment	13	13	13	[997]

5.5 Peloponnese

Table 5.9 presents the results broken down by each impact under each scenario for Peloponnese, while **Table 5.10** breaks out the regional tax (fiscal) impact and employment (annual FTE) impact from a loss of GVA from the tourism and fishing sectors.

Table 5.9: Regional impact for Peloponnese

Impact	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Clean-up	€2.1 million	€2.2 million	€2 million	€3.1 million
Tourism	€9.8 million	€7.6 million	€9.8 million	€186.7 million
Fishing	€1.8 million	€1.8 million	€1.8 million	€32.2 million
Carbon	€61.4 million	€36.7 million	€58.8 million	€61.4 million
Total	**€75.1 million**	**€48.4 million**	**€72.4 million**	**€283.4 million**

Table 5.10: Tax and employment cost breakdown for Peloponnese

Impact	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Tourism – Tax	€1.8 million	€1.4 million	€1.8 million	€34.9 million
Fishing - Tax	€0.3 million	€0.3 million	€0.3 million	€6.0 million
Tourism - Employment	18	14	18	[4,217]
Fishing - Employment	3	3	3	[1,467]

5.6 Western Greece

Table 5.11 presents the results broken down by each impact under each scenario for Western Greece, while **Table 5.12** breaks out the regional tax (fiscal) impact and employment (annual FTE) impact from a loss of GVA from the tourism and fishing sectors.

Table 5.11: Regional impact for Western Greece

Impact	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Clean-up	€1.7 million	€2 million	€1.4 million	€2.5 million
Tourism	€4.1 million	€3.2 million	€4.1 million	€95.5 million
Fishing	€0.6 million	€0.6 million	€0.6 million	€13.3 million
Carbon	€50 million	€29.9 million	€47.9 million	€50million
Total	**€56.5 million**	**€35.8 million**	**€54.1 million**	**€161.4 million**

Table 5.12: Tax and employment cost breakdown for Western Greece

Impact	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Tourism – Tax	€0.8 million	€0.6 million	€0.8 million	€17.9 million
Fishing - Tax	€0.1 million	€0.1 million	€0.1 million	€2.5 million
Tourism - Employment	7	6	7	[2,177]
Fishing - Employment	1	1	1	[611]

5.7 Central Macedonia

Table 5.13 presents the results broken down by each impact under each scenario for Central Macedonia, while **Table 5.14** breaks out the regional tax (fiscal) impact and employment (annual FTE) impact from a loss of GVA from the tourism and fishing sectors.

Table 5.13: Regional impact for Central Macedonia

Impact	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Clean-up	€0.3 million	€0.3 million	€0.2 million	€0.4 million
Tourism	€7.4 million	€5.7 million	€7.4 million	€1,073.6 million
Fishing	€0.5 million	€0.5 million	€0.5 million	€65 million
Carbon	€7.7 million	€4.6 million	€7.3 million	€7.7 million
Total	**€15.8 million**	**€11.1 million**	**€15.4 million**	**€1,146.6 million**

Table 5.14: **Tax and employment cost breakdown for Central Macedonia**

Impact	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Tourism – Tax	€1.4 million	€1.1 million	€1.4 million	€200.6 million
Fishing - Tax	€0.1 million	€0.1 million	€0.1 million	€12.2 million
Tourism - Employment	13	10	13	[25,323]
Fishing - Employment	1	1	1	[3,106]

6. Discussion of the headline costs

6.1 Key findings

The supporting (excel based) model estimates significant costs (especially in terms of impacts on the tourist sector and CO_2 emissions) associated with hydrocarbon exploitation in all four tested scenarios. In the absence of a major spill incident, the cost from the negative impacts are in the range of ~€0.9 billion to €1.3 billion (PV) over the course of the 25-year assessment period.

This is driven by a loss of revenue from the tourism industry through exposure to medium and large-scale spills and the associated reputational damage, along with the high carbon emission costs associated with the exploitation processes. Negative impacts on the fishing industry and the costs of clean-up activities also contribute (to a lesser extent) to the headline total costs. The impact on the fishing sector is small in comparison to the tourist industry in part due to the small size of the Greek fishing economy relative to other European regions. The associated impacts are therefore proportionate to overall size of the fishing industry.

With the occurrence of one, albeit relatively small, major spill incident (i.e. circa 10,000 barrels)[83], the negative economic impacts are expected to be considerably greater. Despite using conservative factors around the size of the spill, it would appear to be reasonable to expect economic damages in excess of €6 billion (PV) over the 25-year assessment period. It is highly complex to model the risks and impacts of a major spill due to the involvement of numerous variables including the size and type of spill, prevailing ocean conditions, weather, effectiveness of the clean-up response, resilience of the environment, and many other factors, but evidence from elsewhere in the world does indicate that if a major spill were to occur, then the negative impacts could be in excess of those estimated in the model.

From both the model results and the literature reviewed, and an understanding of the context of Greece's environment and economy, the economic sector at greatest risk from the concessions is the tourism sector. The direct impacts of a spill, such as beach closures and cancellation of excursions, may actually form a relatively small portion of the overall economic impact. The prevailing literature would suggest that reputational damage following from negative coverage of the impacts of spills on the environment and the recreational opportunities and aesthetic quality that attract tourists, would lead to them taking vacations away from Greece. Furthermore, even in the absence of spills, the presence of oil and gas extraction infrastructure and transportation routes may negatively affect the tourist experience, and the sense of environmental integrity and absence of industry that may drive people's motivation to visit the natural environment. This may cause lasting damage to the appeal for Greece's coastal tourism industry brand.

The model does not directly factor for displacement effects. It is recognised that tourists may decide to visit another part of Greece (especially Greek residents) rather than visit a different country. Equally some visitors may alter their long-term planning in the event of negative perceptions from oil spills but eventually decide to visit the region several years later. The model indirectly factors for displacement effects, through using conservative factors for estimating any negative impacts to the sector. In the event of no major spill (i.e. scenarios 1-3), the total costs to the tourist industry over a 25-year period is estimated at €436 million

[83] *For comparison, the Deepwater Horizon platform spill in the Gulf of Mexico, the largest such spill incident, released an estimated 53,000 barrels per day, and over 4 million barrels in total, while the Prestige tanker spill off the coast of Galicia, Spain, was upwards of 400,000 barrels.*

to €560 million (PV) which is proportionally modest (i.e. ~0.05%) in comparison the Greece's tourism industry, which the World Travel and Tourism Council estimates accounts for approximately 20% of Greece's GDP in 2017 (EUR 35 billion per year)[84]. Even in the event of a single major oil spill, modelled under scenario 4, the impacts on the tourist industry at ~€5billion (PV) over 25 years is still relatively modest (i.e. ~0.5%) compared to total tourism revenue over a 25-year period. It would not be unsurprising that were a major oil spill to occur, that the tourist sector would be affected significantly more than what has been conservatively modelled.

The model also indicates that further consideration is warranted on the potential regional impacts of hydrocarbon exploitation. Perhaps unsurprisingly regions with the largest tourism sector, reliant on their natural environment, face the greatest risk in terms of economic loss from increased hydrocarbon exploitation and the risk of spills. This includes Crete, the Ionian Islands, and Central Macedonia, each of which would be expected to incur losses in excess of €1 billion (PV) in the occurrence of a major spill incident.

In coastal areas where the economy is heavily dependent on tourism, whilst spills may be infrequent any loss in tourism may have longer term consequences within local communities. This vulnerability is likely to be compounded by negative impacts to another prevalent coastal sector like fishing and recreation. Although the fishing industry is relatively small in Greece overall, local coastal economies may be disproportionally affected by losses to this sector. As with impacts to tourism, impacts to the fishing sector may go beyond the initial direct impacts from closures, to wider market effects from negative media attention and reputational damage, leading to a loss of demand and price premium for locally caught harvests.

Additional consideration should also be placed on the carbon emissions associated with extraction activities. Due to the carbon intensive nature of extraction activities (i.e. high unit carbon emissions per unit of oil and gas produced), and the overall quantities of oil and gas to be extracted, this is a major source of the overall negative impact from hydrocarbon exploitation. The model only estimates direct carbon emissions associated with the production of oil and gas, it does not consider indirect emissions (i.e. carbon emissions from the supply chain, such as those associated with the transportation of the produced oil and gas, and embodied carbon in the physical infrastructure required for production), or enabled carbon emissions (i.e. carbon emissions from the consumption of the oil and gas produced), which would add considerably to the overall costs of the hydrocarbon exploitation.

By comparing the estimated benefits with the potential costs, a value can be determined for the level of non-monetised environmental damages that would lead the net benefit to switch to negative. According to the model, this value is €195 to €242 per person in Greece[85] per year[86], depending on the scenario selected. This means that if the environmental damages were to equate to this amount, there is an overall net negative benefit from hydrocarbon exploitation in Greece. Alternately, this can be interpreted as meaning that if every person in Greece were willing to pay this amount, or willing to forego this much economic benefit, to protect the environment from the negative impacts related to hydrocarbon exploitation, then the intervention would result in a net economic loss to Greece.

[84] *World Travel & Tourism Council - TRAVEL & TOURISM ECONOMIC IMPACT 2018 WORLD*
[85] *According to population estimates retrieved January 2019 from: http://www.worldometers.info/world-population/greece-population/.*
[86] *Over the 25-year assessment period.*

6.2 Updating the model

Modelling plausible scenarios is a useful and informative way of estimating the future costs and benefits of hydrocarbon exploitation in Greece. It generates data that can inform decision making by providing an evidence base with which to assess the merits of an activity, policy or development. It enables informed decision making in the presence of lots of uncertainty and consideration of mitigation measures to address any potential negative impacts.

The modelled scenarios provide a guide to a range of potential impacts from hydrocarbon exploitation, rather than a prediction of future impacts. Each scenario is designed to represent a plausible future outcome, which together offer an overall interpretation of what the potential range of impacts may be. Thus, this approach to modelling offers an understanding of the potential impacts of hydrocarbon exploitation, without relying disproportionally on any one assumption or set of assumptions.

There are several ways the model can be improved over time:

1. The inclusion of better information or evidence as it becomes available. The model has been designed to facilitate data updates once more relevant figures are published. Any assumptions used can also be quickly adjusted to reflect the most up to date understanding of the factors involved.
2. The scenarios modelled can be easily amended to draw from the most realistic pathways for each modelled parameter, to reflect the most plausible future pathways as the situation evolves.

As with any study, the results are dependent on the strength of the available data, so any improvements in the quality of available data will build on the model's ability to portray likely future circumstances and provide better support for decision making based on emerging evidence.

6.3 Implications for hydrocarbon exploitation in Greece

The underlying data gathered (see benefit estimates within the model) indicates that there would be significant economic benefits from hydrocarbon exploitation, but also that there would also be economic losses (the main monetised costs assessed being tourist impacts and carbon emissions). Decision making around hydrocarbon exploitation often focuses on the benefits, with less attention paid to potential losses. In part, this is due to a lack of information on the extent of these costs. This study has modelled several of these potential losses and quantified them so that they may be considered alongside the benefits when making decisions about the appropriateness of oil and gas exploitation in Greece.

The model shows that even with a situation approaching a best-case scenario, economic losses are estimated in excess of €1 billion (PV over a 25-year period). It also demonstrates the scale of impact in the event of a major spillage incident, which would lead to an impact several times this value even with relatively moderate assumptions as to its scale and effect. The model also gives some indication as to the potential impact on various sectors and regions, highlighting the vulnerabilities and risks faced by each. There are also important environmental impacts on the marine ecosystem that have not been monetised but should also be considered by policy makers – especially given that the impacts on the environment are relevant both from an ecological and moral perspective, as well as an economic one, given the variety of ecosystem services that the marine environment delivers (see **Annex A**).

Having a better understanding of the implications of hydrocarbon exploitation may lead to better decisions being made, but additionally, the potential recipients of any negative impacts will be better informed and able to voice their interests and concerns.

While an attempt was made to quantify the most significant economic impacts, it was not possible to quantify the potential negative impact on the environment of Greece and its constituent regions. These may be significant and should be taken into consideration. The Greek government would also need to consider the carbon emissions generated by oil and gas extraction towards their overall climate change targets and commitments (e.g. GHG emission reduction targets, uptake of renewable energy, and moving towards a more sustainable circular economy). In the context of data and knowledge limitations to monetise important environmental and social impacts, a precautionary principal may be justified, whereby decisions are made to avoid the risk of irreversible damage where sensitivity and resilience to the impact are unknown.

To maximise the benefits to the people of Greece, its resources must be managed in a way that takes in to consideration both potential benefits and the potential costs of any intervention, including hydrocarbon exploitation. This study begins to fill some important gaps in the knowledge required to make informed decisions by quantifying some of the potential negative impacts which would result in economic loss. This should be weighed against the declared benefits to make the decisions that are best for Greece, its environment and its people.

Conclusion

The assessment of the economic impacts of the exploitation of hydrocarbons in Greece covered in this report and accompanying model demonstrate the **considerable costs that may occur as a result of oil and gas extraction**. Based on the modelled scenarios, the negative impact could be in the range of **€0.8 billion to €1.3 billion** over the course of the 25-year assessment period in the absence of a major spill, and approximately **€5.9 billion** should such a catastrophic event occur. As these figures do not include all potential losses, and do not quantify the potentially severe environmental impacts of hydrocarbon exploitation, they **likely represent an underestimate of the total negative impact**.

While inarguably significant economic benefits may accrue from hydrocarbon exploitation, public debate and policy decision-making should also consider the potential losses associated with the activity. In particular, **the sectoral and regional distribution of such impacts should be taken in to account** when weighing up costs and benefits, as it is likely that the winners and losers from exploitation activities will not be the same sets of stakeholders. The results from this study indicate that **the tourism sector is especially vulnerable to negative economic impact from hydrocarbon exploitation, as are sensitive coastal regions**, such as Crete and the Ionian Islands.

Spills of varying scale are inherent to the oil and gas sector. While major spills are infrequent, they do occur intermittently. However, even more routine medium and large-scale spills will impact Greece's economy and environment, and potentially **shift the structure of the economy, and integrity of the environment, in unintended ways** over time. These concerns must be factored in to any discussion with such **substantial consequences**, in order to ensure that **decision-making is informed to produce the best results for Greece.**

Appendix

A. The risks of hydrocarbon exploitation to Greece

A.1 Likelihood of an oil spill in Greece

A reported "decreasing tendency in the number of accidents since the beginning of the offshore O[il] & G[as] industry in European waters"[87], probably due to the "continuous improvement of the technology used in offshore installations and the implementation of international liability mechanisms"[88], implies that the likelihood of an oil spill in Europe is lower than in previous decades. Despite these improvements, oil spills have nevertheless occurred in Europe and Greece, and engaging in hydrocarbon exploitation is therefore still associated with real risks.

Incidents can occur at various steps of the production process, including transportation of products by ships and the extraction process itself, for example from damaged installations resulting from explosions.[89] Between August 1977 and December 2010, approximately 310,000 tonnes of oil where spilled in the Mediterranean Sea as a result of accidents reported to the Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC). A further 53 accidents occurred in the Mediterranean Sea during this period for which the volume of oil spilled remains unknown and is therefore not included in the aforementioned total oil spill volume.

More than 90% of the spilled oil, approximately 290,000 tonnes, was released as a consequence of incidents with a spill volume above 5,000 tonnes, which the International Maritime Organization describes as major incidents.[90] The majority of these major incidents occurred in the 1970s and early 1980s. They were frequent in the Mediterranean "between 1977 and 1981 and have become rare events since then" [91]. While the biggest share of the spill volume is accounted for by major oil spills, which are rare events nowadays, the "effect[s] of small and middle size oil spills have an important role in pollution, and their effect may be important in the long run"[92]. In fact, small spills, which are monitored by satellite, are frequent. Between 1999 and 2004 alone, more than 9,000 oil slicks were reported in the Mediterranean Sea, the vast majority of which were small incidents.[93]

In fact, while some European spill incidents received a high level of media and scientific attention, resulting in significant information about its consequences, other spills in Europe, which all have environmental consequences, went largely unreported. An example is a spill of 200 tonnes at the North Sea platform *Gannet Alpha* in August 2011. Such minor incidents are also related to significant costs as illustrated by the *Montara* platform incident in the north-west of Australia, where in 2009 a blowout resulted in a release of around 30,000 barrels, i.e. around 4,300 tonnes, of crude oil in addition to an undetermined quantity of

[87] *European Parliament. (2013). The impact of oil and gas drilling accidents on EU fisheries. Brussels: Aberdeen Institute for Coastal Science and Management, p.11*
[88] *Ibid., p.11*
[89] *Ibid.*
[90] *International Maritime Organization. (2011). Statistical analysis: Alerts and accidents database, Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea.*
[91] *Ibid., p.8*
[92] *European Parliament. (2013). The impact of oil and gas drilling accidents on EU fisheries. Brussels: Aberdeen Institute for Coastal Science and Management, p.29*
[93] *Ferraro, G., Roux, M., Muellenhoff, O., Pavliha, M., Svetak, J., Tarchi, D. and K. Topouzelis. 2009. Long term monitoring of oil spills in European seas. International Journal of Remote Sensing, 30(3), 627-645, cited in: European Parliament. (2013). The impact of oil and gas drilling accidents on EU fisheries. Brussels: Aberdeen Institute for Coastal Science and Management.*

gas. As a result, the affected company incurred clean-up costs of 5.3 million Australian dollars and faced compensation claims from Indonesian fishermen and seaweed farmers stating that the environmental damages resulted in lost earnings of more than 1.5 billion Australian dollars per year.[94]

Certain areas bear a higher oil spill risk as a result of their location and specific characteristics. Galicia, in north-western Spain, is one example. The region has historically suffered from a high frequency of spills due to its proximity to one of the busiest global shipping routes and a refinery in one of its ports.[95] As a result, it "suffered five out of the eleven major oil spills in Europe in the last three decades, [i.e. the decades before 2005]"[96]. Greece appears to be another area with a comparatively high risk of an oil spill. According to an analysis of historic data of spills above 100 tonnes, which are deemed to provide the most reliable basis for analysis due to an obligation to report spills of such quantities, Greece is the country with the highest number of such releases in the Mediterranean Sea between 1977 and 2010, accounting for 30% of all releases, followed by Italy and Spain, which account for 18% and 14 % respectively. The high maritime traffic in these regions is stated as the reason behind this distribution.[97] In addition, higher water depth and seismic activity in the region pose particular challenges to oil extraction activities in Greece and other countries in the Mediterranean Sea, leading to a relatively high risk of an oil spill in comparison to other European locations such as the North Sea.[98]

This comparatively high risk in Greece has historically translated to several oil spills with varying extents of damage and might also do so in the future. In 1979, the grounding of the tanker *Messiniaki Frontis* resulted in an oil spill of 12,000 tonnes. Shortly after, in 1980, the explosion of the tanker *Irenes Serenade* lead to a release of 40,000 tonnes of crude oil in the Navarino Bay.[99] Further examples include the *Geroi Chernomorya* collision incident in 1992 resulting in a spillage of 8,000 tonnes of crude oil in the Aegean Sea and the grounding of the tanker *Iliad* in Pylos harbour in 1993. In the subsequent year, the ship *La Guardia* caused a spill of 400 tonnes of heavy crude oil when colliding with refinery supply pipes. In 1996, the tanker *Kriti Sea* spilled 300 tonnes of light crude oil at Agioi Theordori port during loading.[100]

A.2 Consequences of an oil spill

By engaging in additional oil exploration activities, Greece is subjecting itself to a considerable risk of experiencing an oil spill – especially given its comparatively high-risk profile. The risks related to hydrocarbon exploitation in terms of oil spills and their consequences and economic costs have been well illustrated by past oil spills. An analysis of the societal costs of the *Prestige* oil spill – a tanker incident near the coast of Spain – concluded for example that the spillage of 64,000 metric tons of oil polluting more than 1300 kilometres of coastline resulted in societal costs of €770.58 million as a low bound estimate[101]. This includes "[s]hort-term losses in all affected economic sectors, cleaning and recovery costs, and all

[94] *United Nations. (2016). Offshore Hydrocarbon Industries. Retrieved from: http://www.un.org/Depts/los/globalreporting/WOA_RPROC/Chapter_21.pdf*
[95] *Loureiro, M.L., Ribas, A., López, E. and E. Ojea. (2006). Estimated costs and admissible claims linked to the Prestige oil spill. Ecological Economics, 59, 48-63. doi: 10.1016 /j.ecolecon.2005.10.001*
[96] *Ibid., p.49*
[97] *International Maritime Organization. (2011). Statistical analysis: Alerts and accidents database, Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea.*
[98] *European Parliament. (2013). The impact of oil and gas drilling accidents on EU fisheries. Brussels: Aberdeen Institute for Coastal Science and Management.*
[99] *International Maritime Organization. (2011). Statistical analysis: Alerts and accidents database, Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea.*
[100] *International Tanker Owners Pollution Federation Limited (ITOPF). (2011). Greece: Previous spill experience. Retrieved from: https://www.itopf.org/knowledge-resources/countries-territories-regions/countries/greece/*
[101] *Prices in 2001 currency*

environmental losses accountable at this point, [i.e. as of 2005]"[102].

The *El-Jiyeh* oil spill in Lebanon in 2006 resulting in the release of 15,000 tons of oil into the Mediterranean Sea affecting the coastline for 150 kilometres is estimated to have caused damage of US$ 457.8 million (in 2006 prices). These costs, which might have been exacerbated by the Israeli maritime blockade preventing the uptake of mitigation measures for several weeks, consist of direct and indirect oil spill damages (i.e direct and indirect damages of US$ 239.9 million, and the forgone passive use value – a measure of the less tangible benefits of the affected natural environment to society – of US$ 217.9 million). Direct damages include forgone economic activity in terms of fishing, tourism, recreational activities, etc., while indirect damages refer to clean-up and restoration costs.[103]

Environmental impacts

The economic impacts of an oil spill on industries connected to the marine environment, e.g. the fishing and tourism industries, capture parts of the environmental impacts of oil spills by accounting for impacts on commercially viable species and the aesthetic impacts of an oil spill. The environmental impacts of oil spills extend beyond these tangible costs by also affecting species without commercial value.

For instance, oil spills can cause significant harm to a range of species, including birds, fish, terrestrial and marine mammals, reptiles, and microorganisms. The 2002 Prestige oil spill killed approximately 5,000 to 130,000 birds and 33 mammals.[104] After the Amoco Cadiz oil spill, reportedly 37,000 sea birds died.[105] Following the Deepwater Horizon oil spill of 2010, crustaceans (e.g. shrimp and crab) were affected through higher mortality rates.[106]

The extent of the overall environmental impact – including both the impact with and without further commercial implications – is dependent on various factors including the oil distribution, oil chemistry and the type of beach affected.[107]

Past incidents such as the Exxon Valdez oil spill in Alaska occurring in 1989 have illustrated that environmental impacts can be persistent and felt long after the oil spill has occurred. The effects of the oil spill on the Alaskan marine ecosystem were still felt 20 years later.[108] Twenty years after the spill, the Alaskan coast was estimated to have 55,000 litres of oil remaining on 11 hectares of its beaches. Although some species have recovered, such as sea birds and river otters, sea otters and killer whales were still recovering as of 2009, while the herring population was only at 15% of its pre-oil spill size.[109] The spill caused herring to experience premature hatching, genetic abnormalities, and reduced growth rates.[110]

[102] *Loureiro, M.L., Ribas, A., López, E. and E. Ojea. (2006). Estimated costs and admissible claims linked to the Prestige oil spill. Ecological Economics, 59, 48-63. doi: 10.1016 /j.ecolecon.2005.10.001, p.48*
[103] *UNDP Lebanon. (2014). Report on the measurement & quantification of the environmental damage of the oil spill on Lebanon.*
[104] *Loureiro, M.L., Ribas, A., López, E. and E. Ojea. (2006). Estimated costs and admissible claims linked to the Prestige oil spill. Ecological Economics, 59, 48-63. doi: 10.1016 /j.ecolecon.2005. 10.001*
[105] *Grigalunas, T.A., Anderson, R.C., Brown, G.M., Congar, R. Meade, N.F. and P.E. Sorensen. (1986). Estimating the cost of oil spills: Lessons from the Amoco Cadiz incident. Marine Resource Economics, 2(3), 239-262. doi: 10.1086/mre.2.3.42628902*
[106] *Álvarez Waló, N. (2016). Economic impacts of oil spills in island tourism destination. An application to the Canary Islands, Dissertation submitted to Universidad de La Laguna.*
[107] *World Bank. (2007). Republic of Lebanon: Economic assessment of environmental degradation due to July 2006 hostilities.*
[108] *Álvarez Waló, N. (2016). Economic impacts of oil spills in island tourism destination. An application to the Canary Islands, Dissertation submitted to Universidad de La Laguna.*
[109] *Dorsett, M. (2010). Exxon Valdez oil spill continued effects on the Alaskan Economy, Colonial Academic Alliance Undergraduate Research Journal, 1, Article 7.*
[110] *US Department of the Interior. (2016). An Analysis of the Impacts of the Deepwater Horizon Oil Spill on the Gulf of Mexico Seafood Industry. New Orleans: The Vertex Companies.*

In the case of an oil spill in Galicia, Spain, in 2002, it was estimated that recovery would take 2-10 years in regard to damage to local biodiversity.[111] Some impacts even start to materialize years after the oil spill. Alaska for example experienced a sudden collapse of the fish population three years after the Exxon Valdez oil spill.[112]

Some of the studies reviewed attempted to value environmental damages in monetary terms. The non-market value of the mammals lost after the Exxon Valdez spill for example was estimated to be between $20,000 and $300,000 per marine mammal and $170 to $6,000 per seabird and eagle.[113] As a result of the Prestige oil spill, the total estimated value of the damage to the bird population was €6.4 million[114], while the total estimated biodiversity loss was €863.3 million[115].

Aside from direct harm from the spilled oil, e.g. through ingestion, the impacts on animals are also resulting from damages caused to their habitats. The Deepwater Horizon oil spill damaged several habitats, including oyster reefs, salt marshes, seagrasses, mangroves, coral reefs and estuaries.[116] Apart from impacting on animals, the damages caused to habitats also have the potential to negatively affect the provision of numerous ecosystem service benefits delivered by marine ecosystems (e.g. climate regulation through carbon dioxide sequestration, protection against coastal erosion, etc.).

Economic impacts

While the fishing industry is directly affected by an oil spill through its impact on animals and the resulting reduction in catch volumes, oil spills can also affect the fishing industry indirectly through influencing public perception of the region's products and their safety, which ultimately has the ability to reduce seafood demand and prices. This can further exacerbate the impact of an oil spill on the fishing industry. In fact, in Louisiana, fishermen believed that market perception was more significant in impacting seafood demand, compared to the ecological effect.[117] After the spill, the oil company BP provided $2 million upfront to finance a crisis communication campaign in order to combat distorted information and bad press regarding seafood consumption and tourism.[118]

Regardless of the accuracy of the perception, evidence from historic oil spills has demonstrated that fishing and tourism sectors are significantly affected by public perceptions following oil spills. Following the Deepwater Horizon spill, seafood distributers reported a fall in demand for Gulf seafood, leading some distributors to shut down.[119] Local fisherman in Louisiana stated a struggle with selling seafood as a result of concerns over food safety.[120] In attempt to solve this problem, BP paid the Louisiana Seafood Promotion

[111] *World Bank. (2007). Republic of Lebanon: Economic assessment of environmental degradation due to July 2006 hostilities.*
[112] *Fall, J.A., Miraglia, R., Simeone, W. Utermohle, C.J. and R.J. Wolfe. (2001) Long-Term Consequences of Exxon Valdez Oil Spill for Coastal Communities of Southcentral Alaska. Technical Paper No. 264. Division of Subsistence, Alaska department of Fish and Game, Juneau, Alaska, cited in: World Bank. (2007). Republic of Lebanon: Economic assessment of environmental degradation due to July 2006 hostilities.*
[113] *Cleveland, Cutler J. (2008). Exxon Valdez Oil Spill, the Encyclopedia of Earth, National Ocean and Atmosphere Association, quoted in: Dorsett, M. (2010). Exxon Valdez oil spill continued effects on the Alaskan Economy, Colonial Academic Alliance Undergraduate Research Journal, 1, Article 7.*
[114] *Loureiro, M.L., Ribas, A., López, E. and E. Ojea. (2006). Estimated costs and admissible claims linked to the Prestige oil spill. Ecological Economics, 59, 48-63. doi: 10.1016 /j.ecolecon.2005.10.001*
[115] *Garza, M.D., Prada, A., Varela, M. and M.X. Vazquez Rodriguez. (2009). Indirect assessment of economic damages from the Prestige oil spill: consequences for liability and risk prevention. Disasters, 33(1), 95-109. doi: 10.1111/j.0361-3666.2008.01064.x*
[116] *US Department of the Interior. (2016). An Analysis of the Impacts of the Deepwater Horizon Oil Spill on the Gulf of Mexico Seafood Industry. New Orleans: The Vertex Companies*
[117] *Greater New Orleans, inc. (2010). A study of the economic impact of the Deepwater Horizon oil spill. New Orleans: IEM.*
[118] *US Department of the Interior. (2016). An Analysis of the Impacts of the Deepwater Horizon Oil Spill on the Gulf of Mexico Seafood Industry. New Orleans: The Vertex Companies.*
[119] *Greater New Orleans, inc. (2010). A study of the economic impact of the Deepwater Horizon oil spill. New Orleans: IEM.*
[120] *US Department of the Interior. (2016). An Analysis of the Impacts of the Deepwater Horizon Oil Spill on the Gulf of Mexico Seafood Industry. New Orleans: The Vertex Companies.*

and Marketing Board $30 million dollars to restore the image of the seafood brand.[121]

Similar indirect effects are possible in regard to the tourism industry. The media can affect tourists' opinions in the aftermath of an oil spill. While widespread knowledge can positively influence the clean-up efforts through an increase in volunteers and donations, the negative coverage of the spill can cause tourists to consider the area unsafe to visit. Sensationalised coverage can cause a misunderstanding that the whole country, for example, was affected rather than a smaller region within the country.

In addition to media coverage, public perception about the severity of the oil spill and the resulting danger for the population can also be influenced by other factors such as government action. After the Amoco Cadiz oil spill for example, the French government called for oysters and other seafood thought to be affected by the oil spill to be removed from the market to avoid human health effects resulting from ingesting food.[122] In addition to the short-term effects on the fishing industry, such government-induced bans have the potential to affect consumer demand in the long run by reinforcing consumer worries about health risks, potentially to an irrational extent.

With respect to tourism, impacts on demand have been observed in the aftermath of historic oil spills. After the Deepwater Horizon oil spill, 26% of tourists planning on visiting the region cancelled or postponed their trips.[123] The long-term impacts on demand seem however to be limited as illustrated by the Exxon Valdez oil spill near the coast of Alaska, where tourist numbers returned to normal within 2 years after the clean-up.[124] Public administration expenditure incurred to remedy such effects can be significant. In Galicia, €31 million was spent in an effort to repair the region's image as a desirable holiday destination.[125]

A.3 Greece's vulnerability to an oil spill

The vulnerability of Greece to the consequences of an oil spill play an important role for understanding the cost and benefits of hydrocarbon exploitation in Greece. This vulnerability depends in part on the extent to which it relies on and/or benefits from the services provided by the maritime environment which would be negatively impacted by an oil spill. As of 2004, 90% of all tourism and recreation activities took place near the coast.[126] This suggests that tourists' decision about whether to consider Greece as a holiday destination for future vacation and about whether to cancel booked trips is likely to be affected by offshore oil spills – much more so than if tourism would have been concentrated in inland areas. A study evaluating the ecosystem services (i.e. the products and services contributing to human well-being provided by the natural environment), provided by Mediterranean marine ecosystems (i.e. meadows, corallogenic concretions, rocky and soft seabeds and the open sea), concluded that services of a value of €3.147 billion per year are delivered.[127] A breakdown of the economic values of specific types of ecosystem services delivered to Greece is provided in **Table A. 1**.

[121] *Ibid.*
[122] *Álvarez Waló, N. (2016). Economic impacts of oil spills in island tourism destination. An application to the Canary Islands, Dissertation submitted to Universidad de La Laguna.*
[123] *Ibid.*
[124] *Ibid.*
[125] *Ibid.*
[126] *Policy Research Corporation. (n.a). Country overview and assessment: Greece. Retrieved from European Commission website on Maritime Affairs: https://ec.europa.eu/maritimeaffairs/sites/maritimeaffairs/files/docs/body/greece_climate_change_en.pdf*
[127] *Mangos, A., Bassino, J-P. and D. Sauzade. (2010). The economic value of sustainable benefits rendered by the Mediterranean marine ecosystems. Plan Bleu, Valbonne. (Blue Plan Papers 8).*

Table A. 1: Economic value of benefits rendered to Greece by the Mediterranean marine ecosystem

Ecosystem service benefits		**Value of the contributions (in millions of € in 2005 prices/year)**	
Provision of food resources		588	
Provision of amenities and recreational supports	Hotel and restaurant service activities	680	2075
	Real estate	1078	
	Tourism	317	
Climate regulation		98	
Protection against coastal erosion		173	
Waste treatment		212	
Total		3147	

Source: Mangos, A., Bassino, J-P. and D. Sauzade, (2010) - Adapted version of Table 5 on p.48

Comparing the economic value of benefits rendered to Greece by the Mediterranean marine ecosystems to another Mediterranean country, Tunisia, it was found that “Greece draws more advantage from the contributions made by marine ecosystems, since the value of its benefits is 6 times greater than that of Tunisia”[128]. The economic value of these ecosystem services represented 1.6% of Greek’s Gross National Product in 2005. The composition of the total value of benefits delivered by the Mediterranean marine ecosystems also differs between countries. In Greece, the provision of amenities and recreational supports – accounting for 66% of the overall value of ecosystem service benefits delivered to Greece – is making a bigger contribution to the total value of delivered ecosystem services than in Tunisia, where the provision of amenities and recreational supports accounts for 49%.[129]

A wide variety of actors are the beneficiaries of the ecosystem services – with some benefitting financially and others benefitting from other forms of improved well-being or welfare. In the case of food provision, for example, fishermen and related businesses benefit economically from these ecosystem service, while their clients may additionally benefit from the availability of a high quality local food source.[130] An oil spill thus may negatively impact both companies in or related to the seafood and tourism sectors, as well as their clients, which includes Greek residents and also residents of other countries. Climate regulation and the protection against coastal erosion can also potentially be affected by an oil spill if it leads to a reduction of plant abundance in affected habitats.

Damage to marine habitat’s ability to prevent coastal erosion appear to be of lesser concern in Greece, where the rate of coastal urbanisation - a major driver of the value of the provision of erosion protection – is very low in regional comparison.[131] Furthermore, erosion is mainly a concern in soft coastal areas (i.e. at sandy beaches, dunes and wetlands), and the majority of the Greek coastline, around 70%, consists of rocky coasts[132] limiting its vulnerability to a loss of habitat’s erosion protection ability. This is not to say that the effect of oil spill on natural coastal erosion protection is negligible everywhere in Greece. In regions with soft coasts, which “currently experience a high rate of erosion”[133], this potential consequence of an oil spill should not be ignored, especially given that “no coordinated actions are undertaken in the field of coastal

[128] *Ibid., p.48*
[129] *Ibid.*
[130] *Ibid.*
[131] *Ibid.*
[132] *Policy Research Corporation. (n.a). Country overview and assessment: Greece.*
[133] *Ibid., p.2*

protection [...] and measures are decided upon in an ad-hoc way by different national authorities and implemented by local municipalities"[134].

In addition, it is important to note that, "oil confrontation in Greece appears to be rather expensive, with a value of about 25,000 euro for the abatement of a spill of one ton of oil"[135]. The total oil spill response cost incurred is, however, very case-specific and depends on a variety of factors including the oil type, the clean-up method used and its effectiveness, with mechanical cleaning being more than twice as expensive as the use of chemical dispersants. In terms of habitats affected, cleaning up areas consisting of rocks, soil or sand is generally cheaper than the clean-up process in the open water, or cleaning-up wetlands.[136]

[134] *Ibid., p.3*

[135] *Ventikos, N.P., Chatzinikolaoy, S.D. and G. Zagoraios. (2009). The cost of oil spill response in Greece: analysis and results, Proceedings of International Maritime Association of Mediterranean, 12–15 October, Istanbul, Turkey, cited in: Kontovas, C.A., Psaraftis, H.N. and N.P. Ventikos. (2010). An empirical analysis of IOPCF oil spill cost data. Marine Pollution Bulletin, 60, 1455-1466. doi: 10.1016/j.marpolbul.2010.05.010, p.1457*

[136] *Schmidt Etkin, D. (2004). Modelling oil spill response and damage costs, US EPA Archive Document. Retrieved from: https://archive.epa.gov/emergencies/docs/oil/fss/fss04/web/pdf/etkin2_04.pdf*

B. Development of a Cost-benefit analysis

B.1 Cost-benefit analysis

To assist in the assessment, a cost-benefit analysis (CBA) model was produced that can be exploited once greater certainty is known about the model parameters, such as the level of oil and gas reserves.

In the context of hydrocarbon exploitation in Greece, a CBA can be used to compare the costs and benefits of exploitation to determine the net benefit of the investment. The standard approach to CBA consists of several steps:

- Define the objective;
- Establish the baseline and intervention impacts;
- Measure costs and benefits of impacts in monetary terms;
- Analysis of costs and benefits; and,
- Sensitivity analysis.

The first step of the CBA is to define the objective, namely an economic appraisal of the costs and benefits of hydrocarbon exploitation in Greece over time, based on a range of plausible development scenarios. The approach allows for the comparison of costs and benefits in the same unit of measure, money, to gain understanding of their relative scale. The information generated can be used in decision-support regarding whether the intervention is a sound investment for Greece, considering the net effects in economic activity at national and regional level.

The second step concerns the identification and specification of the baseline and impact. The analysis conducted considers the development of hydrocarbon exploitation in Greece relative to the absence of such development. A 25-year time horizon (2019-2044) is applied, which was chosen after a review of both the EU Guide[137] (15-25 years for energy sector) and the licence that the Greek Government issued in West Katakolon in November 2016 (25 years).

The impacts scoped in to the assessment were chosen due to their materiality to the Greek economy. These are:

- Benefits:
  - Economic (increase to GVA)
  - Employment (direct and indirect job creation)
  - Tax revenue (through concession fees, royalties and corporate tax)
- Costs:
  - Clean-up (direct costs)
  - Tourism (loss of GVA)
  - Fishing (loss of GVA)
  - Carbon (cost of emissions associated with extraction)

[137] *Policy, U. (2008). Guide to cost-benefit analysis of investment projects. The EU.*

Table B. 1 briefly describes each parameter with an outline of the formula applied in its calculation, the adopted data and assumptions employed, and the various pathways developed as sensitivity ranges.

Table B. 1: Parameter calculation summaries

Parameter	Description	Formula	Data used	Assumptions	Pathways (i.e. sensitivity ranges)
Price of oil	The oil price refers to the spot price of one barrel of the crude oil, i.e. Brent blend oil, used as benchmark.	No formula needed	1. Oil Price Summary with projection to 2050 from US Energy Information Administration (EIA).	1. Assumed that the price sensitivity band (% increase/decrease) is 10%.	1. Price of oil is 10% lower than projected, due to reduced demand and higher than expected supply; 2. Price of oil follows current EIA projections (Annual Energy Outlook 2018); 3. Price of oil is 10% higher than projected, due to increased demand and lower than expected supply; 4. Price of oil rises sharply to peak at $200/barrel by 2040.
Level of reserves	Oil reserves are an estimate of the amount of crude oil available at each site.	Estimated level of reserves per site in million barrels of oil, with a constant level of extraction over the assessment period to depletion.	1. Low and High estimation of reserves provided by WWF Greece.	1. Assumed a medium estimation of reserves; 2. Assumed Constant level of extractions over assessment period to depletion; 3. Concession estimates are split between regions where they overlap.	1. Lower quantity of reserves projected; 2. Middle quantity of reserves projected; 3. Higher quantity of reserves projected.
Rate of extraction	The level of extraction is an estimate of the amount of crude oil to be extracted at each site per year.	Estimated level of reserves per site in million barrels of oil with a constant level of extraction over assessment period to depletion.	1. Low and High estimation of reserves provided by WWF Greece.	1. Assumed a medium estimation of reserves; 2. Assumed Constant level of extractions over assessment period to depletion.	1. Lower rate of extraction based on lower value of reserves projected; 2. Middle rate of extraction based on medium value of reserves projected; 3. Higher rate of extraction based on higher value of reserves projected.

Extraction cost (including transport)	The extraction cost shows the expenditures required to produce a barrel of oil.	Estimate of the production cost of a barrel of oil.	1. EC data on the crude supply cost by country; 2. Oil Prices and the Global Economy by International Monetary Fund; 3. Transportation cost from Association of Oil Pipe Lines (AOPL).	1. One pathways assumes an annual reduction in cost of extraction of 1% due to greater efficiencies and technological improvements.	1. Low cost of extraction - extractions on offshore shelf 2. Middle cost of extraction-extractions in deep water 3. High cost of extraction - "ultra" deep water 4. Decreasing cost of extraction - due to technological efficiencies (e.g. extraction machinery and processes)
Employment impact	The employment impact estimates the effect of hydrocarbon exploitation in terms of the number of jobs created.	Employment impact = Direct employment from oil and gas production + (direct employment from oil and gas production * employment multiplier)	1.World Bank Sustainable Energy Department estimates on direct and indirect job creation per sector; 2. Multipliers per sector from a study on monitoring of sectoral employment commissioned by the European commission paper; 3. Wages average per sector based on AMECO database.	1. Assumed an employment coefficient (Employment/Oil production in barrel), based on Norkpetroelum database. 2. Assumed proportion of jobs to be filled by the Greek labour market (50%). 3. Average salary is an assumption based on data from AMECO database and the fact that wages have fallen significantly in recent years in Greece (€ 16,000).	1. Direct employment – employment coefficient per volume extracted (Norway); 2. Direct employment – multiplier per 1$ million of spending (cost of extraction)(World Bank); 3. Direct and indirect employment - multiplier per 1$ million of spending (cost of extraction)(World Bank);
Tax revenue	The tax impact estimates the amount of taxes related to hydrocarbon exploitation activities.	Tax impact (per site) = Concession fee[138] + royalties[139] + corporation tax[140]	1.Taxation rates provided by WWF Greece; *2.Greek annual concession fee from € 200 to € 2,000 per square kilometre;* *3. Greek royalties of 2% to 20% based on production efficiency;* *4. Greek rate of 25% tax rate on corporate profits.*	*1.Assumed corporate tax avoidance/evasion rate (25%);* 1. Royalties have been estimated based on medium estimate price of oil, level of extraction, and extraction cost only.	1. Lower tax impact based on lower value of reserves projected; 2. Middle tax impact based on lower value of reserves projected; 3. High tax impact based on lower value of reserves projected.

[138] *Greek annual concession fee from £200 to £2000 per square kilometre.*
[139] *Greek royalties of 2% to 20% based on production efficiency.*
[140] *Greek rate of 25% tax rate on corporate profits.*

Economic impact	The economic impact measures the economic value added by hydrocarbon exploitation.	Economic impact = ((Cost of extraction * Quantity extracted) * (GVA/turnover) * Multiplier) – (employment impact)[141]	1.Multipliers from Ioannina SEA publication; 2.GVA/turnover estimate from ELSTAT data.	1. Assumed 25% of expenditure leakage (i.e outside Greece)	1. Lower value based on lower of extraction projected; 2. Middle value based on medium value of extraction projected; 3. Higher value based on higher value of extraction projected.
Spill risk and volume	The risk of spill estimates the probability of oil spill per barrel produced/transported.	Expected spill = Expected number of 'Small' oil spills* volume + expected number of 'Medium' oil spills * volume + expected number of 'Large' oil spills * volume	1.The data for risk and volume of small, medium large spills is estimated by The Bureau of Safety and Environmental Enforcement (BSEE).	1. Assumed 10,000 barrels for a 'major spill'; 2. The major spill is modelled as occurring in year 12, the mid-point of the assessment, for the purposes of discounting; 3. Assumed 'high risk' equates to proportional uplift of 1.5; 4. Assumed that spill is proportionally distributed across regions.	1. Low extraction, average risk; 2. Middle extraction, average risk; 3. High extraction, average risk; 4. Middle extraction, high risk – high risk equals 50% increase in spills; 5. Pathway 2, but with a major spill in year 12 (mid-year of the assessment)
Clean-up cost	This parameter provides an estimation of the costs incurred for clean-up activities required after an oil spill.	Clean-up impact = Average per unit marine oil spill clean-up cost in Greece * Weight of oil spilled	1. European Commission data on the average per unit marine oil spill clean-up cost in Greece.	1. No assumptions needed.	1. Low extraction, average risk; 2. Middle extraction, average risk; 3. High extraction, average risk; 4. Middle extraction high risk – high risk equals 50% increase in spills; 5. Major spill in 12 years (based on Pathway 2)

[141] *Note that economic impact is net of employment impact and reported separately for presentational purposes.*

Tourism impact	This parameter estimates the possible effects on the tourism industry.	Tourism impact = Risk of spill * estimated % impact * value of tourism sector GVA by region * tourism sector growth rate * Economic multiplier * impact to tax revenues from sector	1.Growth of tourism estimate from World Travel & Tourism Council; 2. Economic multiplier from SETE; 3. Travel receipts by region statistics from Bank of Greece; 4. Oil spill impacts on tourism revenue from Oxford Economics estimates. 5. GVA/turnover estimate from ELSTAT data; 6. Tax contribution estimate from Hellenic Statistics.	1. Assumed cumulative impact from medium spills (conservative impact) - i.e. medium spill is 5% impact of major spill impact; 2. Assumed cumulative impact from medium spills (conservative impact) - i.e. medium spill is 25% impact of major spill impact; 3. Assumed that relatively routine small spills do not have an impact on tourism; 4. Assumed no macro impact from loss of domestic tourism (due to substitution).	1. Medium spills only; 2. Medium and large spills; 3. Medium and large spills + major spill (low); 4. Medium and large spills + major spill (high); 5. Minor spills + major spill (Lingering impact)
Fishing impact	This parameter estimates the possible effects on the fishing industry.	Fishing impact = Risk of spill * estimated % impact * value of sector GVA by region * fishing sector growth rate * Economic multiplier * impact to tax revenues from sector	1.Fisheries sector by region data from the European Parliament; 2.Impact from reputational damage data estimates based on a historic evidence and European Parliament data; 3. Economic multipliers from ELSTAT data; 4. GVA/turnover estimate from ELSTAT data; 5. Tax contribution estimate from Hellenic Statistics.	1. Assumed fishing sector growth rate of 1%.	1. Minor spills; 2. Minor spills + major spill (Low); 3. Minor spills + major spill (High); 4. Minor spills + major spill (Lingering impact)
Carbon impact	A carbon impact is a cost applied to carbon pollution generated through the extraction of oil and gas	Carbon impact = CO_2 per tonne of oil extracted * Carbon price	1.Tonnes of CO_2 per thousand tonnes of production from International association of Oil & Gas producers; 2.Price of carbon emissions from EEX group and Synapse Energy Economics.	1. Assumed price of carbon emission increase by 50% by 2030 based on OECD estimate leads to 4.5% increase as a sensitivity.	1. Carbon follows actual price 2. Carbon price follow OECD prediction 3. Carbon price follow Synapse prediction

B.2 Generic CBA formula

In developing the CBA model, the annual benefits and costs over the assessment period are aggregated in present value (discounted) terms. The formal calculations are presented below.

$$\mathbf{PVB} = \sum_{i=0}^{25} \left(\frac{1}{1+r}\right)^{i} * \boldsymbol{Benefits}_{\,i}$$

Where PVB is present value benefit, i is an index for the year and r is the discount rate.

$$\mathbf{PVC} = \sum_{i=0}^{25} \left(\frac{1}{1+r}\right)^{i} * \boldsymbol{Costs}_{\,i}$$

Where PVC is present value cost, i is an index for the year and r is the discount rate.

Costs and benefits are compared in present value terms. The net present value (NPV) of an intervention is calculated as the difference between Present Value of the Benefits (PVB) and the Present Value of the Costs (PVC):

$$\mathbf{NPV} = \mathbf{PVB} - \mathbf{PVC} = \left[\sum_{i=0}^{25} \left(\frac{1}{1+r}\right)^{i} * \boldsymbol{Benefits}_{\,i}\right] - \left[\sum_{i=0}^{25} \left(\frac{1}{1+r}\right)^{i} * \boldsymbol{Costs}_{i}\right]$$

B.3 Limitations of approach to CBA

The CBA uses GVA as a measure of economic impact. Although this may not be equivalent to the measurement of economic surplus (or welfare creation), it is a reasonable measure of economic contribution for the purposes of this model, with the available data.

In regard to the additionality of impacts, the model includes assumptions around leakage for the benefits from employment (i.e. external labour market) and economic impact (i.e. external supply chain) but does not explicitly address additionality for the costs side losses (i.e. to the tourism and fishing industries). This implicitly assumes that for these impacts, losses do not just represent a substitution in demand from one region to another, but rather that net losses accrue to Greece (i.e. impacts are additional to Greece, averaged across regions). As these impacts are predominantly due to reputational damage, which would likely apply to the whole of the Greek tourism or seafood brands, this is a reasonable assumption.

As more refined estimates of additionality would rely on additional assumptions, it is not thought that there would be added value from greater precision in terms of the accuracy achieved. This is a pragmatic approach due to limitations of the available data.

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