ECONOMIC AND ENVIRONMENTAL

Impacts of Oil and Gas Development Offshore the Delmarva, Carolinas, and Georgia

BY:

TIMOTHY J. CONSIDINE

DISTINGUISHED PROFESSOR OF ENERGY ECONOMICS

COLLEGE OF BUSINESS

DEPARTMENT OF ECONOMICS & FINANCE

SCHOOL OF ENERGY RESOURCES

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Timothy J. Considine, Ph.D.
Distinguished Professor of Energy Economics
College of Business
Department of Economics & Finance
School of Energy Resources
University of Wyoming

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About Dr. Considine

Tim Considine is the School of Energy Resources (SER) Distinguished Professor of Energy Economics at the University of Wyoming (UW) in the Department of Economics and Finance. He joined SER in August 2008, after serving as a professor of natural resource economics at The Pennsylvania State University for 22 years.

Prior to his academic career, he worked as an analyst with the U.S. Congressional Budget Office from 1981 to 1983, receiving the Outstanding Service Award for his studies of natural gas market deregulation. He then worked as an economist with the macroeconomic forecasting unit in Bank of America, winning the Silbert Award for most accurate macroeconomic forecast, after predicting the sharp decline in oil prices during 1986.

He recently completed several studies on the economic and environmental impacts of shale energy development, which were sponsored by the Marcellus Shale Coalition, Manhattan Institute, and the American Petroleum Institute. He also has received research support from the American Iron and Steel Institute, Wyoming Mining Association, National Science Foundation, U.S. Environmental Protection Agency, U.S. Energy Information Administration, U.S. Department of Energy, the governments of Israel and Australia, and the World Bank.

In addition to shale energy, his other recent research projects include the economics of energy efficiency and conservation programs in Jackson, Wyoming, process innovations in the iron casting industry, the impacts of renewable portfolio standards on electricity rates in California and Arizona, and engineering-economic modeling of unconventional oil and gas supply.

Professor Considine currently teaches a course in energy economics in the Masters of Business Administration program and a popular undergraduate course on the history of the oil industry.

He holds a Ph.D. degree from Cornell University (1981), an M.S. from Purdue University (1977), and a B.A. with honors from Loyola University of Chicago (1975).

Executive Summary

Prior to the recent boom in oil production from shale formations in the U.S., offshore oil production had been a main source of new supply for the world oil industry. These new supplies came from offshore Brazil, Angola, Nigeria, India, Egypt, Norway, the United Kingdom, and several other countries. While the U.S. remains a leader in offshore oil production based in the central and western Gulf of Mexico, 87 percent of offshore areas in the U.S. are ruled off-limits to new oil and gas drilling.

The U.S. Department of Interior considered holding a lease sale off Virginia in 2009 but that proposal was removed from consideration after the Macondo well blowout in the Gulf of Mexico during 2010. Lease sales off the Atlantic seaboard, however, are possible during the next leasing period that starts in 2018. The advocates of these sales tout the economic and fiscal benefits of oil and gas development. Opponents cite the costs associated with environmental impacts. This study estimates and compares these economic, fiscal, and environmental impacts for an area that includes the Mid Atlantic Outer Continental Shelf (OCS) off the Delmarva – Delaware, Maryland, and Virginia – and North Carolina, and the South Atlantic OCS off the coasts of South Carolina and Georgia.

The study recognizes that there are uncertainties associated with not just how much oil and gas may be offshore but also with how society may value the economic and social costs associated with environmental emissions. Three production scenarios, summarized in Figure ES1 below, are formulated based upon the distribution of previous estimates of ultimate technically recoverable reserves (UTRR) in the study area. Besides uncertainty, Figure ES1 also illustrates the long-lead times for oil and natural gas development. Even if leases were sold in 2018 meaningful production would begin roughly 7 years later in 2025.

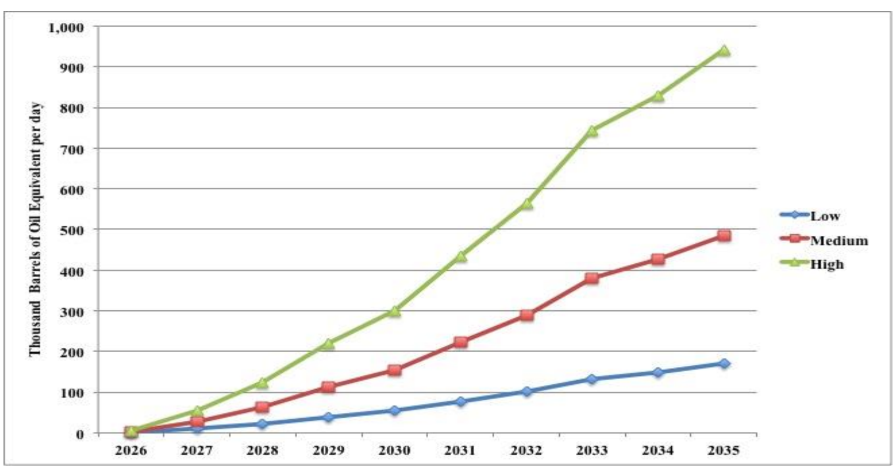

Figure ES1: Offshore Oil & Gas Production Scenarios for Study Area

Under the high production scenario, output in the study area reaches 943,000 barrels of oil equivalent per day in 2035, which includes 388,000 barrels of crude oil and natural gas production of 555,000 barrels per day of oil equivalent (or 3 billion cubic feet of natural gas per day). This scenario results in cumulative production of roughly 1.5 billion barrels by 2035 so that remaining reserves in 2035 are more than 21.9 billion barrels of oil equivalent. Given this reserve base, the decision to hold lease sales should be viewed as an opportunity to create a long-term asset that pays substantial income in the form of royalties. The medium production scenario has production at over 484,000 barrels of oil equivalent per day while the low scenario has production at 169,000 barrels per day in 2035. Given the recent remarkable improvements in oil and gas production technology, the odds for the medium to high production scenarios are good.

The required investment and operating expenses to achieve these production levels are illustrated in Figure ES2 below. Under the high production scenario, spending reaches $2.0 billion in 2025, $8.1 billion in 2030, and $10.7 billion in 2035. The medium and low production scenarios envision spending of $5.5 and $1.9 billion in 2035. These spending levels are based upon a detailed cost engineering study of oil and gas development in the Atlantic OCS conducted by Quest Offshore (2013)[1].

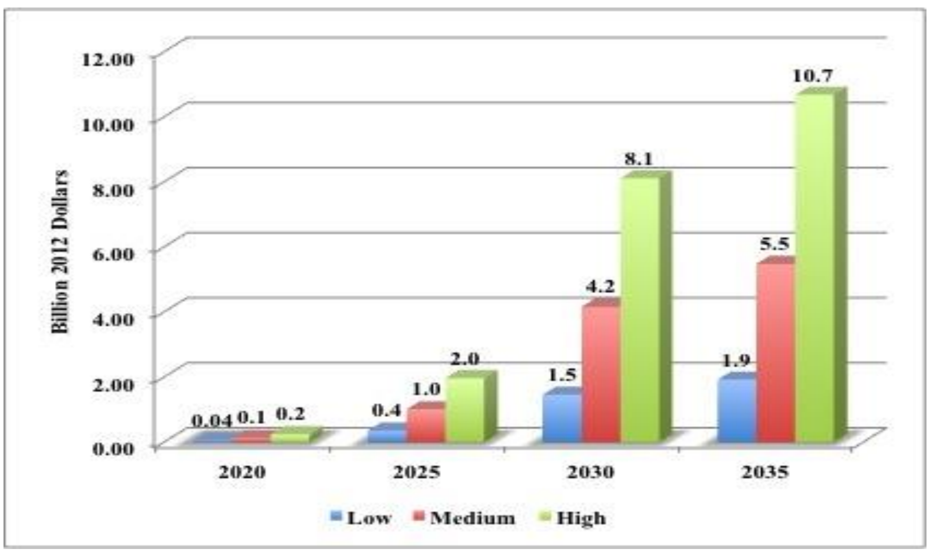

Figure ES2: Offshore Oil & Gas Development Spending in Study Area

The spending during the construction and operation of offshore oil and gas production facilities will have several economic impacts. The capital expenditures will *directly* stimulate support industries. For example, capital expenditures for the construction of oil and gas wells involve direct purchases from companies that provide capital equipment, engineering and construction services, and other goods and services.

[1] http://www.api.org/~/media/Files/Oil-and-Natural-Gas/Exploration/Offshore/Atlantic-OCS/Executive-Summary-Economic-Benefits-of-Increasing-US-Access-to-Atlantic-Offshore-Resources.pdf.

These companies in turn acquire equipment and supplies from other companies, stimulating several rounds of *indirect* spending throughout the supply chain. The direct and indirect outlays generate additional employment and income, which *induce* households to spend their income on additional goods and services. Together, these direct, indirect, and induced impacts during construction and operation constitute the total economic impacts of energy investments. These impacts are estimated with multipliers derived from input-output models of the economy.

The economic benefits estimated in this study are calibrated to those estimated by Quest Offshore (2013), which are derived from multipliers using the Regional Impact Modeling System developed by the Bureau of Economic Analysis in the U.S. Department of Commerce. Fiscal impacts include lease sale and royalty income and state and local taxes. Two sets of environmental impacts are considered. The first set includes impacts associated with air emissions, specifically greenhouse gases and other emissions. Market models for oil and natural gas are used to determine how additional production from the study area reduces market prices, displaces production outside the region, and increases consumption of oil and gas, which leads to higher emissions. For the case of greenhouse gas emissions, this study uses the social cost of carbon estimate by the Interagency Task Force on the Social Cost of Carbon. Similar calculations are conducted for the expected costs associated with oil spills. The economic, fiscal, and environmental impacts are summarized in Table ES1 for the study area in five-year increments across the three production and environmental valuation scenarios.

Table ES1: Economic, Fiscal, and Environmental Impacts

	Millions of 2012 Dollars unless otherwise noted*			
	2020	2025	2030	2035
	Low Production & Environmental Valuation Scenarios			
Value Added	70	405	1,637	2,408
Royalties & Leases	25	27	170	583
State & Local Taxes	3	19	78	116
Employment (Jobs)*	832	5,312	21,230	30,694
Environmental Impacts	0	0	38	187
	Medium Production & Environmental Valuation Scenarios			
Value Added	201	1,155	4,675	6,878
Royalties & Leases	73	77	485	1,664
State & Local Taxes	10	55	224	330
Employment (Jobs)*	2,377	15,174	60,642	87,674
Environmental Impacts	0	0	324	1,502
	High Production & Environmental Valuation Scenarios			
Value Added	392	2,251	9,110	13,401
Royalties & Leases	141	149	946	3,243
State & Local Taxes	19	108	437	643

Employment (Jobs)*	4,632	29,565	118,157	170,828
Environmental Impacts	0	0	1,878	8,830

The valuation scenarios are most affected by the social cost of carbon, which can be viewed as a fee to compensate society for the environmental impacts of greenhouse gas emissions. Three scenarios are considered: a low track with prices between $13 and $21 per ton of carbon, a medium trajectory between $42 and $63 dollars per ton of carbon, and a high path between $120 and $195 per ton. With the three production scenarios, there are nine possible outcomes. In the interests of parsimony, this study presents three of those nine cases in Table ES1, which captures the range of possible outcomes. Given that the environmental impacts move in proportion to output, the implied benefit-cost ratios for each valuation scenario across the three possible production scenarios are the same.

Value added or gross regional product (GRP) builds over time in all three scenarios in proportion to the levels of investment and operating spending reported in Figure ES2 above. Eight years after lease sales are permitted in 2018 under the low production scenario, value added is $405 million higher in 2025 than if sales were not allowed. By 2035, allowing lease sales generates an additional $2.4 billion in value added under the low production scenario. Also under this scenario, lease sales and eventual development increases employment by nearly 31,000 by 2035.

Considerably higher value added is generated under the more likely medium and high production scenarios. Under the medium scenario, value added is $1.16 billion higher in 2025, $4.7 billion higher in 2030, and $6.9 billion higher in 2035. Employment gains are also significant at over 15,000 in 2025, over 60,000 in 2030, and more than 87,000 in 2035 (see Table ES1). The high scenario shows gains in value added of $2.3 billion in 2025, $9.1 billion in 2030, and $13.4 billion in 2035. Employment gains are over 29,000 in 2025, nearly 118,000 in 2025, and almost 170,000 in 2035.

In 2025, oil and gas lease and royalty payments to states in the region range from $27 to $149 million from the low to high production scenarios. Once production is well underway in 2030, these payments rise to between $170 and $946 million. By 2035, lease and royalty payments are between $583 million and $3.2 billion (see Table ES1). Even under the low production scenario, the gains in oil and gas income to states are non-trivial. They are rather significant under the medium and high production scenarios.

The impacts on state and local taxes are lower than those gains from oil and gas income but remain nevertheless significant with additional state tax revenue in the region from $116 million under the low production scenario to over $640 million under the high production scenario by 2035.

Environmental impacts are incurred once production begins after 2025. Under the low production scenario and low valuation of emissions, environmental impact costs are $187 million in 2035. Recall these estimates in this scenario are for carbon prices that vary between $13 and $22 per ton. With higher carbon prices between $42 and $63 per ton, environmental impact costs rise to $1.5 billion in 2035. Finally, under rather extraordinary carbon prices between $121 and $195 per ton and much higher unit damages associated with oil spills, environmental impact costs approach $8.8 billion.

The natural question at this juncture is how the benefits of offshore oil and gas development compare with the environmental costs. Incremental value added is a good measure of the economic benefits. Under the low production scenario, incremental value added is $2.4 billion while environmental costs are $187 million in 2035 (see Table ES1). The medium production scenario with higher prices for environmental impacts results in sharply higher environmental impact costs of $1.5 billion, but they remain substantially below the $6.9 billion gain in value added during 2035. Finally, under the high production scenario with extremely high environmental emission prices, the costs of environmental impacts rise to $8.8 billion but remain well below the $13.4 billion increase in value added (see Table ES1).

To provide a more consistent and expansive comparison of the benefits and costs of offshore drilling, the discounted present value of incremental value added and environmental costs are computed from 2017 to 2035, assuming a 3% discount rate, which is very close to prevailing 20 year Treasury bond yields. This also facilitates a comparison of economic, fiscal, and environmental impacts across the six states in the study area in Table ES2.

Under the low production scenario, the region gains $10.8 billion in value added over the entire period and incurs a $395 million cost related to environmental impacts. The implied benefit-cost ratio of 27 for this scenario is high because environmental valuations are so low. The medium scenario with carbon prices between $42 and $63 per ton has environmental costs of $3.2 billion compared with economic benefits of over $30.8 billion. While environmental costs are considerably higher for this scenario, the economic benefits exceed costs by nine-to-one. With extraordinarily high carbon prices approaching $200 per ton under the high production scenario the benefit-cost ratio declines from the medium scenario but, even so, economic benefits exceed environmental costs by a ratio of three-to-one. Hence, across all three scenarios, benefits substantially exceed costs. These findings suggest that allowing lease sales in the Atlantic OCS study area would incur costs, but the benefits are far larger. Hence, allowing sales of Atlantic OCS oil and gas leases would increase social welfare.

The ranking of the states is clear, with North Carolina, South Carolina, and Virginia the largest winners if Atlantic offshore oil and gas production is allowed. Under the high production scenario, North Carolina could realize over $24.5 billion in economic output, $4.3 billion in additional tax revenues (see Table ES2), and on average employment levels that are nearly 30,000 higher each year over the 2017 to 2035 period (see Table ES2). South Carolina also may experience significant economic benefits with over $14.5 billion in additional economic output, $3.5 billion in more tax revenues, and nearly 17,000 jobs per year. Virginia is a close third, with over $13.2 billion in economic product, $2.0 billion in tax revenues, and 13,200 more jobs annually over the forecast period.

These gains, however, should be tempered by the economic costs associated with the environmental impacts summarized by state in Table ES2. These impacts, however, are considerably smaller than the gains in value added. For example, even for the high production scenario with very high estimates for carbon prices (upwards of $195 per ton) environmental costs are $6.9 billion for North Carolina compared with $24.5 billion in incremental value added, implying a benefit-cost ratio of approximately 4. The benefit-cost ratios are much higher with the medium estimate for environmental valuations of damages. The results suggest that the economic benefits of offshore oil and gas development are likely to far exceed the economic value of environmental damages.

Table ES2: Economic, Fiscal, and Environmental Impacts by State

	Present Discounted Value in Million 2012 Dollars				
	Value Added	Tax Revenues	Environmental Impacts	Average Annual Full-Time Equivalent Jobs	Benefit - Cost Ratio*
	Low Production & Environmental Valuation Scenarios				
North Carolina	4,403	774	144	5,366	31
South Carolina	2,616	637	133	2,982	20
Virginia	2,383	360	67	2,377	36
Georgia	416	118	20	449	21
Maryland	569	103	16	565	36
Delaware	400	91	15	344	27
Total	10,787	2,084	395	12,084	27
	Medium Production & Environmental Valuation Scenarios				
North Carolina	12,577	2,212	1,187	15,328	11
South Carolina	7,472	1,820	1,095	8,518	7
Virginia	6,806	1,029	552	6,791	12
Georgia	1,189	338	166	1,283	7
Maryland	1,626	294	129	1,615	13
Delaware	1,143	260	123	983	9
Total	30,812	5,953	3,251	34,518	9
	High Production & Environmental Valuation Scenarios				
North Carolina	24,506	4,310	6,943	29,866	4
South Carolina	14,558	3,546	6,405	16,597	2
Virginia	13,262	2,005	3,227	13,231	4
Georgia	2,316	659	970	2,499	2
Maryland	3,168	574	753	3,147	4
Delaware	2,227	506	718	1,915	3
Total	60,036	11,599	19,015	67,255	3

* Value Added / Environmental Impacts

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1. Introduction

The widespread adoption of technological innovations in horizontal drilling, hydraulic fracturing, and multi-dimensional seismic imagining has enabled the United States to regain its position as the largest oil and gas producer in the world. Crude oil and natural gas liquids production increased from 6.9 to 10.0 million barrels per day from 2007 to 2013, with nearly all of this gain coming from North Dakota, Texas, Oklahoma, Colorado, and other western states. Production continues to climb and recently reached 10.9 million barrels per day during the first four months of 2014. This additional production has been critical in replacing lost oil supply from the Middle East and North Africa, thereby moderating world oil prices.

Likewise, U.S. natural gas production is also up sharply, increasing from 19.2 trillion cubic feet (TCF) in 2007 to 24.3 TCF in 2013, a record, with all of this increase coming from shale gas resource plays, particularly from the Marcellus, Utica, and Upper Devonian formations in Pennsylvania, West Virginia, and Ohio. Relatively cheap and abundant natural gas is encouraging the expanded use of natural gas in petroleum products, chemical and metal manufacturing, power generation, and transportation. Moreover, several projects are underway to export liquefied natural gas.

These investments are building a very sizable base of industrial infrastructure dependent upon natural gas. A key uncertainty is whether natural gas supply will keep pace with this growing base of natural gas use. Maintaining robust and diverse sources of natural gas supply will be critical in maintaining and expanding the economic benefits derived from higher oil and gas production, including a lower U.S. trade deficit, higher tax revenues, and more good jobs at high wages.

Most of this higher oil and natural gas production has occurred on privately held lands in Texas, North Dakota, Pennsylvania, Colorado, Wyoming, Oklahoma, and Louisiana. These states have experienced significantly higher state and local tax revenues as well as additional revenues from mineral leasing and royalties. The higher state and local tax revenues are generated from the additional business that oil and gas development creates throughout the economy. Moreover, oil and gas jobs on average pay over $70,000 per year, more than double average annual earnings for other sectors. Given these benefits, many states bypassed by the shale gas and oil boom in the U.S. are evaluating the prospects and the potential for encouraging oil and gas development in their regions. The Mid and South Atlantic states, for example, which have been looking at the potential of offshore oil and gas production for more than a decade, are once again making a concerted effort to open access to offshore regions and encourage companies to invest and convert potential reserves of oil and gas to actual production.

Another long-term strategic consideration is energy supply diversification. Under the current slate of regulations for toxic, criteria, and greenhouse gas emissions promulgated by the U.S. Environmental Protection Agency, a very sizable amount of coal-fired electric power generation capacity is being converted from coal to natural gas in the Mid and South Atlantic region. Several projects are underway to build additional pipeline capacity to transport Marcellus natural gas to the region. So the southeastern region of the U.S. will become increasingly dependent upon Marcellus gas. While abundant and low-cost supplies make this an attractive option now, markets can change. Investments to develop additional supplies from the mid and South Atlantic region will protect consumers from possible price spikes or inter-regional supply problems in the future. Finally, these additional supplies would augment the ability of the U.S. to export energy to Europe and reduce their dependency on Russian oil and gas, which is critically important after the Ukrainian experience this year.

Currently, there is no offshore oil and gas development in this region due to federal inaction to hold sales of oil and gas leases. This inaction in part results from a series of moratoriums enacted after the oil well blowout and oil spill off the Santa Barbara, California coast in 1968. In reaction, President Nixon imposed a drilling ban for offshore California waters that was subsequently extended to other areas by his successors. As a result, more than 87 percent of offshore areas in the U.S. are currently off-limits for oil and gas development.

This situation stands in sharp contrast to other areas around the world. Until the recent oil production boom in the U.S., offshore oil development had been a main source of new supply for the world oil industry. These new supplies have come from offshore Brazil, Angola, Nigeria, India, Egypt, Norway, the United Kingdom, and other countries. Despite limited access, the U.S. remains a leader in offshore oil development with nearly all production coming from the western and central Gulf of Mexico that is open to production. So offshore oil development is well established around the world and the United States has considerable untapped potential, particularly off the Atlantic coast.

These investment opportunities, however, are precluded until the federal government sells offshore oil and gas exploration leases. This decision will follow a public process in which various groups voice their concerns on the relative merits of allowing these sales. On one side, the oil and gas industry argues that development generates the aforementioned economic benefits. Opponents of oil and gas development, however, often cite adverse environmental impacts, such as the economic, human health, and ecological damages associated with oil and gas production and consumption. State policy makers are caught in this crossfire and must weigh the economic benefits with the environmental impacts. The objective of this study is to conduct an economic analysis that sheds light on the relative size of these costs and benefits from offshore oil and gas development. Our focus is on the mid and South Atlantic region encompassing six states: Delaware, Maryland, and Virginia – the so-called Delmarva – and North Carolina, South Carolina, and Georgia.

The analysis in this report builds upon the previous study of oil and gas development off the Atlantic coast by Quest Offshore (2013) supported by the American Petroleum Institute. This study addresses two issues not addressed by the Quest Offshore (2013) study: uncertainty and environmental impacts. One argument against development is that there may not be significant reserves. Policy makers need an understanding of the range of uncertainty that exists around reserve estimates and in particular how economic and environmental impacts are affected by this uncertainty. Accordingly, the next section of this report quantifies this uncertainty and develops three production scenarios that will likely bracket the possible outcomes if drilling is permitted.

Another argument often advanced against oil and gas development is that the environmental impacts are overwhelmingly negative and could very well offset any economic and fiscal benefits. Concerns over greenhouse gas emissions are paramount from this perspective and as a result, this study estimates the impact of the production scenarios on greenhouse gas emissions and estimates their economic value using prices for carbon emissions from the Interagency Task Force on the Social Cost of Carbon (2013). Estimates of the expected value of costs associated with oil spills and other environmental damages, such as methane leaks, are also considered. Like the production scenarios, uncertainty is considered in estimating these environmental impacts. By considering the economic value of environmental impacts, this study provides policy makers with data, information, and analysis to weigh the costs and benefits of Atlantic offshore oil and gas development.

From this unifying perspective of cost-benefit analysis, section three below presents our findings for the entire six-state study area. Section four presents the results for each state. Both sections classify impacts into three categories: economic, fiscal, and environmental. Overall, the analysis provides policy makers with a framework for understanding whether development of oil and gas reserves is in the best interest of their constituents by balancing the goals of preserving environmental quality, stimulating economic growth, and fostering energy independence.

2. Oil and Gas Development Scenarios

The Atlantic Outer Continental Shelf (OCS) spans the waters from Nova Scotia to the Straits of Florida, containing 269 million acres. The four parts of this region are depicted in Figure 1. The study region for this report is defined to include the Mid Atlantic coast off the Delmarva and North Carolina and part of the South Atlantic region off the coasts of South Carolina and Georgia.

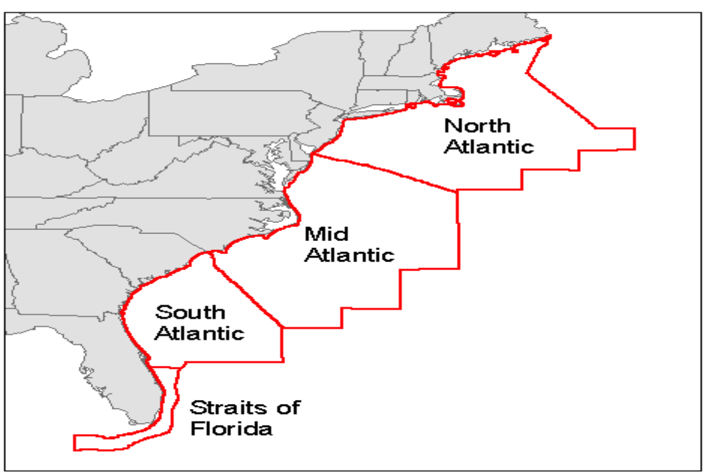

Figure 1: Atlantic Outer Continental Shelf Planning Areas

Oil and gas lease sales took place in the Atlantic OCS between 1976 and 1983 in the mid and south Atlantic regions. The U.S. Bureau of Ocean Management (2013) planned on holding a sale in the Mid Atlantic region during the five-year planning period 2007-2012. This lease sale, which included 2.9 million acres 50 miles off the shore of Virginia, was expected to take place in 2011 but was removed from consideration following the Macondo accident in the Gulf of Mexico in 2010.

According to the Bureau of Ocean Management (BOEM), 240,000 miles of two-dimensional seismic imaging was shot in the Atlantic OCS from the late 1960s to the mid-1980s. Very limited amounts of three-dimensional seismic imaging, which is more informative, were taken in 1982. No seismic imaging has been undertaken since the early 1980s. The absence of advanced seismic imaging contributes to greater uncertainty surrounding estimates of oil and gas resources in the region.

Drilling in the region has been very limited, with only 51 wells drilled between 1975 and 1984. Exploratory efforts drilled 47 wells in shallow waters, but they drilled only 4 wells in deep waters, which have a greater potential for large reserves. The Royal Dutch Shell Company drilled three wells in waters nearly 7,000 feet deep in the Mid-Atlantic region. Tenneco and Texaco drilled a well off New Jersey in 1984 and discovered natural gas, but that discovery was deemed uneconomical due to the low natural gas prices at the time.

Given the extremely limited amount of geophysical information, estimates of potential oil and gas reserves in the region are highly uncertain. Possible future production is determined by estimates of potential reserves. The U.S. Bureau of Ocean Management (2011) identified ten unique but overlapping resource plays off the Atlantic Outer Continental Shelf and estimated that ultimate total recoverable reserves (UTRR) are 8.87 billion barrels of oil equivalent (BOE), see Figure 2. Previous estimates by the Mineral Management Service (MMS), the predecessor of the BOEM, and the United States Geological Survey (USGS) are also displayed in Figure 2, with estimates ranging from a high of over 11 billion BOE to as low as 1 billion BOE, see Figure 2.

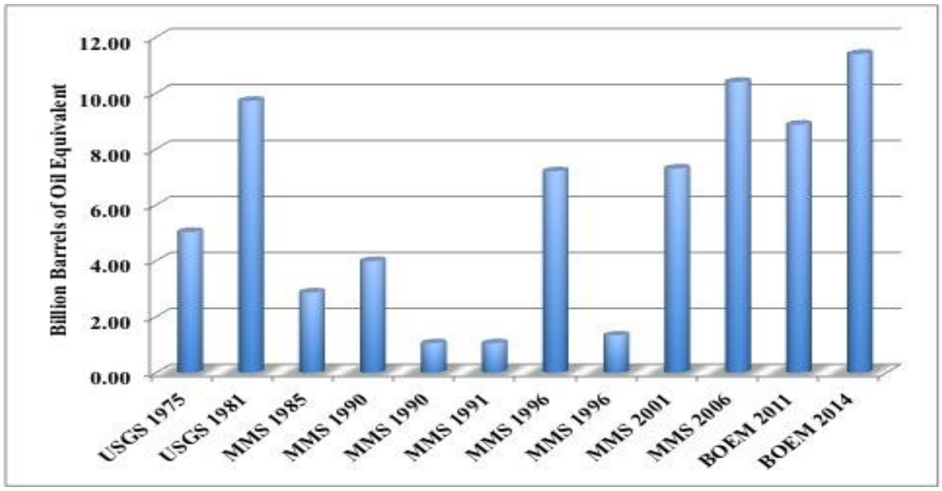

Figure 2: Atlantic Offshore Oil & Gas Reserve Estimates

Initial reserve estimates are inherently conservative. Actual reported proven reserves tend to grow over time as operators learn the physical features of the field. To account for this reserve growth phenomenon, Quest Offshore (2013) estimates a multiplier to scale up initial estimates of UTRR based upon experience in the Gulf of Mexico. Their multiplier is 2.06. For example, Quest Offshore (2013) converts the BOEM 2011 initial reserve estimate of 8.87 by multiplying by 2.06 to obtain a realized UTRR of 18.3.

To estimate the uncertainty, this study takes the estimated UTRRs displayed in Figure 2, multiplies them by 2.06, and then computes the mean and standard deviations of the resulting estimated realized UTRRs. The mean of these realized UTRRs for the Atlantic OCS is 12.1 billion BOE. The standard deviation is 7.8 billion BOE, which provides a low estimate of 4.2 billion BOE (11 – 7.3). The high estimate for the realized UTRR is the maximum of the sample at 23.5 billion BOE (see Table 1, second column).

Table 1: Formulation of Reserve and Production Scenarios

	Billion BOE			
		Production 2025-35		
Scenario	Realized UTRR	Atlantic OCS	Study Area	Ratio to High Scenario
Low	4.2	0.5	0.28	0.18
Medium	12.1	1.3	0.79	0.51
High	23.5	2.6	1.54	1.00

These three scenarios for estimated UTRR are used to estimate three production scenarios. For the high scenario in Table 1 with an estimated UTRR of 23.5 billion barrels, 2.6 billion barrels of BOE are produced from 2025 to 2035 (see Table 1), assuming leasing begins in 2018 and production commences 7 years later. The ratio of the medium to the high realized UTRR multiplied by 2.0 billion barrels of BOE gives an estimated cumulative production of 1.3 billion BOE in the medium scenario (see Table 1). Since this is based upon the mean of the reserve estimates reported above, this medium scenario could be construed as the expected value of realized UTRR.

Cumulative production in the study area from 2025 to 2035 is 1.5 billion BOE (see Table 1), which again corresponds with the high resource scenario. Cumulative production in the study area is estimated to be 0.79 and 0.28 billion BOE for the medium and low scenarios based upon the cumulative production to reserve ratios in the high scenario (see Table 1).

The trajectories of crude oil and natural gas production for these scenarios are plotted below in Figures 3 and 4. Under the high resource scenario, crude oil production begins in 2025 and ramps up to over 387,000 barrels of oil per day by 2035. Natural gas production reaches almost 3,026 million cubic feet (mcf) per day by 2035. The production profiles for the low and medium scenarios are estimated by multiplying these levels by the ratios in the last column of Table 1.

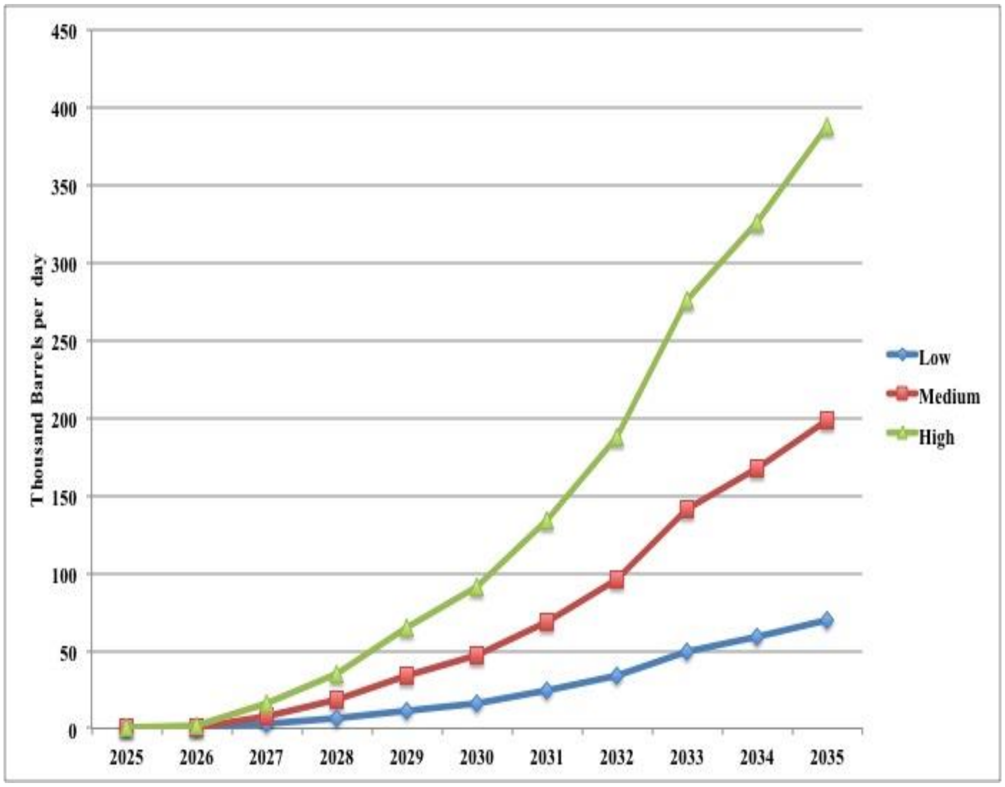

Figure 3: Study Area Crude Oil Production Scenarios

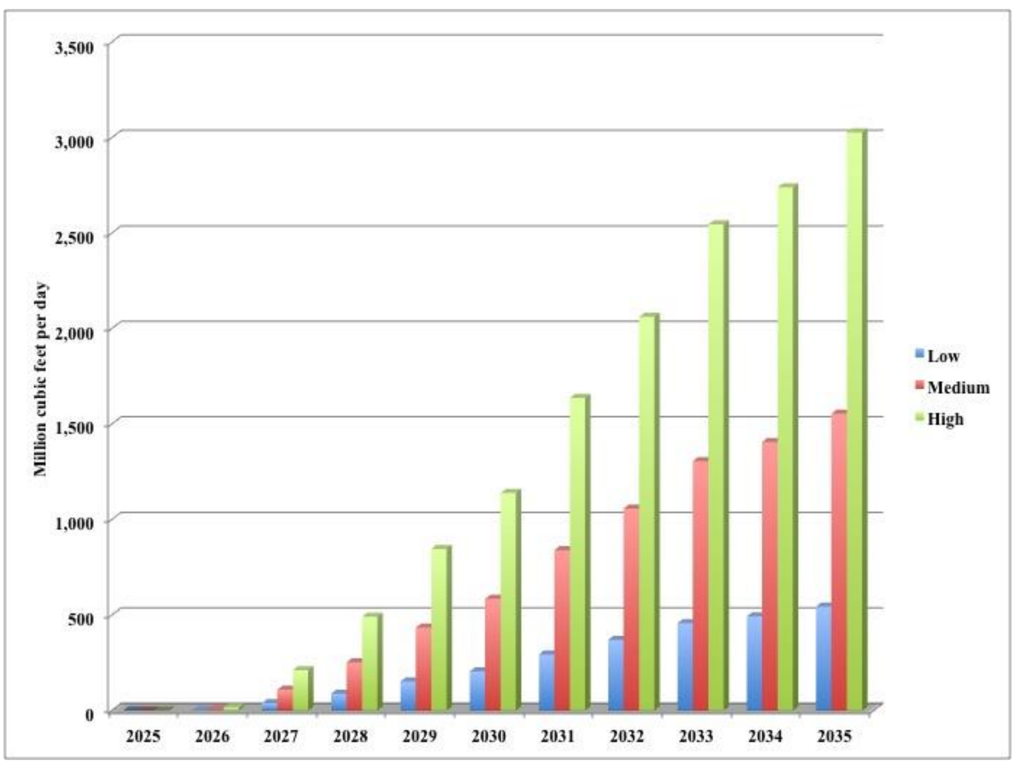

Figure 4: Study Area Natural Gas Production Scenarios

Under the high resource scenario, to produce 1.5 billion barrels of oil equivalent by 2035, $83.4 billion of capital outlays and operating expenses would be incurred from 2017 to 2035. The path of these outlays over time under this scenario is presented in the last column of Table 2. The spending levels under the low and medium scenarios are calculated by multiplying the levels of spending under the high scenario by the ratio of production in any given year by the scaled cumulative production associated with that particular scenario (see columns 2&3, Table 2).

Table 2: Investment Spending for Oil & Gas Region in Study Region

	Million 2012 Dollars		
Year	Low	Medium	High
2017	9	25	49
2018	26	74	144
2019	30	87	170
2020	43	123	240
2021	55	157	306
2022	78	222	432
2023	164	468	911
2024	273	780	1,520
2025	354	1,011	1,969
2026	631	1,803	3,513
2027	832	2,375	4,628
2028	1,044	2,981	5,808
2029	1,278	3,652	7,115
2030	1,457	4,162	8,109
2031	1,640	4,684	9,126
2032	1,663	4,749	9,254
2033	1,716	4,902	9,552
2034	1,774	5,067	9,872
2035	1,919	5,481	10,679

3. Regional Impacts

Associated with each of these production and spending scenarios are economic, fiscal, and environmental impacts. For this study, economic impacts include two common measures: value added and employment generated by the spending levels presented above in Table 2. Value added is also referred to as gross domestic product at the national level or gross regional product for states or counties. Employment is measured in this study in terms of full-time equivalent jobs. Fiscal impacts include state and local taxes and revenues earned from oil and gas lease sales and royalty payments. Environmental impacts include the economic value of the impacts that air and water emissions and land impacts have on the economy. These three sets of impacts – economic, fiscal, and environmental – are discussed in each of the sections below.

3.1 Economic Impacts

The economic impacts of offshore oil and gas development involve two stages. First, there are the impacts on value added, jobs, and tax revenues during the construction of the rigs and infrastructure both on and offshore. During the second phase, economic impacts arise during the operation of these facilities as the income generated from these facilities is spent.

The spending during the construction and operation of offshore oil and gas production facilities will have several economic impacts. The capital expenditures will *directly* stimulate support industries. For example, capital expenditures for the construction of oil and gas wells involve direct purchases from companies that provide capital equipment, engineering and construction services, and other goods and services. These companies in turn acquire equipment and supplies from other companies, stimulating several rounds of *indirect* spending throughout the supply chain. The direct and indirect outlays generate additional employment and income, which *induce* households to spend their income on additional goods and services. Together, these direct, indirect, and induced impacts during construction and operation constitute the total economic impacts of energy investments.

Regional economic impact analysis using input-output (IO) tables and related IO models provides a means for measuring these economic impacts. Input-output analysis provides a quantitative model of the inter-industry transactions between various sectors of the economy. This framework provides a means for estimating how spending in one sector affects other sectors of the economy. This re-spending through the economy initiating from an exogenous increase in investment spending or production generates multiplied impacts on value added, employment, and tax revenues.

These impacts are summarized in metrics called multipliers that translate how oil and gas investments and operating expenses affect employment and value added. The study by Quest Offshore (2013) used multipliers derived from the Regional Impact Modeling System II (RIMSII) produced by the U.S. Bureau of Economic Analysis in the U.S. Department of Commerce. This study computes the value added and employment multipliers implicit in the Quest Offshore study and the results of these computations for the states in our study region are presented in Appendix B. These are so-called Type II multipliers that include the direct, indirect, and induced impacts discussed above. The value added multipliers average 1.3, meaning that for every dollar of oil and gas investment and operating outlay, value added increases 1.3 dollars. The average employment multiplier is 15.6 full-time equivalent jobs per million dollars of spending on investment and operations.

Value added is defined as gross revenues or sales less purchases of intermediate goods, hence, it represents a net contribution to the economy in the form of payments to workers as wages and salaries, to investors as dividends and bond payments, and to governments as taxes and fees. Building offshore oil and gas rigs requires hiring additional workers. The additional business activity generated by this stimulus to overall supply chain and the spending of wage income by the newly employed in the oil and gas industry and supply-chain related industries increases the demand for labor throughout the economy.

The job gains reported below should be interpreted as the additional jobs created in each year. Unlike value added that can be added over time to estimate cumulative gains in gross regional product, employment gains cannot be added over time because jobs created in one year could be continued in the next. Hence, adding annual employment gains over time would lead to double counting.

The total economic impacts across the six-state region are reported below in Table 3. Value added or gross regional product (GRP) builds over time in all three scenarios in proportion to the levels of investment and operating spending reported in Table 2 above. Five years after lease sales are permitted in 2018 under the low production scenario, value added is $113 million higher in 2022 than if sales were not allowed. By 2035, allowing lease sales generates an additional $2.4 billion in value added under the low production scenario. Also under this scenario, lease sales and eventual development increase employment by more than 30,000 by 2035 (see column 5, Table 3).

Table 3: Economic Impacts of Oil & Gas Development in Study Region

	GRP - Million 2012 Dollars			Full Time Equivalent Jobs		
Year	Low	Medium	High	Low	Medium	High
2017	11	32	63	130	370	721
2018	41	118	230	507	1,448	2,821
2019	47	135	262	568	1,623	3,162
2020	70	201	392	832	2,377	4,632
2021	87	248	482	1,158	3,307	6,443
2022	113	324	631	1,520	4,341	8,458
2023	206	587	1,144	2,593	7,408	14,434
2024	302	862	1,680	4,007	11,444	22,299
2025	405	1,155	2,251	5,312	15,174	29,565
2026	692	1,977	3,852	9,328	26,645	51,917
2027	916	2,616	5,097	12,242	34,967	68,131
2028	1,165	3,329	6,486	15,671	44,764	87,219
2029	1,442	4,119	8,026	19,216	54,888	106,946
2030	1,637	4,675	9,110	21,230	60,642	118,157
2031	1,869	5,339	10,403	24,372	69,617	135,644
2032	1,950	5,569	10,851	25,487	72,802	141,851
2033	2,108	6,020	11,730	27,165	77,595	151,188
2034	2,182	6,234	12,146	27,569	78,749	153,438
2035	2,408	6,878	13,401	30,694	87,674	170,828

Considerably higher valued added is generated under the more likely medium and high production scenarios. The high production scenario shows gains in value added of $631 million in 2022, $2.251 billion in 2025, and $13.4 billion in 2035. Employment gains are over 8,400 in 2022, over 29,000 in 2025, and over 170,000 in 2035. Under the medium scenario, value added is $324 million higher in 2022, $1.2 billion higher in 2025, and $6.8 billion higher in 2035. Employment gains are also significant at over 4,300 in 2022, over 15,000 in 2025, and more than 87,000 in 2035 (see Table 3).

3.2 Fiscal Impacts

State policy makers are keenly interested in how oil and gas development can impact state budgets. Developing oil and gas resources generates two main streams of income. First, there is direct income that flows from the state's share of federal lease sales and royalty payments. This study adopts the same assumption made by Quest Offshore (2013) that states receive 37.5% of these lease sale and royalty payments. The projections of oil and gas lease and royalty income are consistent with the projections for oil and gas prices published in the Annual Energy Outlook (2013) by the Energy Information Administration.

The second source of tax revenues for states comes from higher state and local tax collections. Unlike the Quest Offshore (2013) this report provides an estimate of these revenues by multiplying the tax rates reported below in Table 4 by the estimated gains in value added reported in Table 3. These tax revenues include property taxes, sales and gross receipt taxes, license taxes, income taxes, and other taxes, including death and gift taxes and stock transfers.

Table 4: State Tax Revenues as a Percent of Value Added

North Carolina	5.10%
South Carolina	4.66%
Virginia	4.24%
Georgia	3.92%
Maryland	5.48%
Delaware	5.58%
Region	4.67%

The results of these calculations are reported in Table 5. In 2020, oil and gas lease and royalty payments to states in the region range from $25 to $141 million from the low to high production scenarios. Once production is underway in 2030, these payments rise to between $170 and $946 million. By 2035, lease and royalty payments are between $582 million and $3.2 billion (see Table 5). Even under the low production scenario the gains in oil and gas income to states is non-trivial; revenues are rather significant under the medium and high production scenarios.

The impacts on state and local taxes apart from the oil and gas specific revenues stream are reported in the last three columns of Table 5. Overall, these tax revenue streams are lower than those gains from oil and gas income but nevertheless remain significant with additional state tax revenue increases in the region from $115 million under the low production scenario to over $643 million under the high production scenario by 2035.

In summary, the fiscal condition of the region would be improved if oil and gas lease sales and production occur. If development proceeds and is as successful as the high production scenario projects, annual state revenue collections would be $3.8 billion higher. This additional income could be used to retire state debt or to fund education, medical care, and other social services. These findings suggest that from a state's perspective, the fiscal impacts of oil and gas development may be one of the more compelling motivations for supporting federal oil and gas lease sales. These monies could be earmarked for transportation needs or to help the unfunded liabilities of state and local retirement funds. Indeed, for some states, such as Wyoming, with significant levels of mineral production, oil and gas lease payments and royalty income are so significant that state income taxes are not levied.

Table 5: Fiscal Impacts of Oil & Gas Development in Study Region

	Million 2012 Dollars					
	Oil & Gas Leases & Royalties			State & Local Taxes		
Year	Low	Medium	High	Low	Medium	High
2017	0.0	0.0	0.0	0.5	1.6	3.0
2018	12.5	35.6	69.4	2.0	5.6	11.0
2019	13.2	37.6	73.3	2.2	6.4	12.5
2020	25.4	72.6	141.4	3.4	9.7	18.8
2021	26.3	75.2	146.5	4.2	11.9	23.1
2022	28.2	80.5	156.8	5.4	15.5	30.2
2023	27.2	77.8	151.7	9.8	28.0	54.6
2024	27.7	79.2	154.2	14.5	41.4	80.7
2025	26.8	76.5	149.1	19.3	55.2	107.6
2026	28.4	81.3	158.3	33.1	94.6	184.4
2027	55.8	159.2	310.3	43.9	125.3	244.1
2028	86.0	245.7	478.8	55.8	159.4	310.6
2029	126.0	359.9	701.3	69.1	197.4	384.7
2030	169.9	485.3	945.7	78.5	224.2	436.8
2031	225.4	643.8	1,254.5	89.7	256.3	499.3
2032	294.3	840.6	1,637.8	93.6	267.4	521.1
2033	407.2	1,163.2	2,266.5	101.1	288.7	562.5
2034	473.8	1,353.5	2,637.2	104.7	299.1	582.7
2035	582.7	1,664.5	3,243.2	115.5	330.0	642.9

3.3 Environmental Impacts

The oil and gas production scenarios developed above will have a range of environmental impacts. The key question is whether the economic costs associated with these impacts are commensurate with the economic benefits estimated above. Producing and consuming oil and natural gas affect the natural environment, including air, land, and water resources. These impacts directly affect society by reducing the flow of services from these natural resources. For example, offshore oil production involves the risk of oil spills, which incurs cleanup costs and degrades water resources that would affect related economic activities, such as fishing and recreation. Likewise, additional oil production and consumption would increase emissions of greenhouse gases that contribute to global climate change.

Indeed one of the more cogent arguments against developing the untapped oil and gas is that additional production would add to greenhouse gas emissions when the world is trying to combat the impacts of global climate change. The extent of this increase, however, is somewhat tempered because higher production originating from the Atlantic OCS would be partially offset by reductions in oil and gas production elsewhere. In other words, not all of the increase in regional oil and gas production represents an increase in world consumption of these products. The extent of this offset depends upon how world supply and demand for oil and gas adjust to Atlantic OCS production. Higher oil and gas production from the Atlantic OCS displaces imports and (depending upon the size of the production increase) reduces market prices, which discourages production outside the region and increases world consumption. This study uses estimates for these market adjustments reported in the literature to estimate the net increase in world oil and gas consumption resulting from changes in oil and gas production from the study region. The methods used for these computations are reported in Appendix A.

How could production here lessen production elsewhere given a growing world population and an increasing demand for electricity here and all over the world? Energy markets fall in two major segments: mobile uses of energy for which oil has at present a virtual monopoly, and stationary uses of energy in which many fuels compete, including coal, natural gas, solar, wind, hydroelectric, and nuclear power. The oil displacement estimated in this study, therefore, would not induce significant competition with other fuels. Moreover growing energy demand due to population growth would in itself put upward pressure on oil prices. Additional supplies from the Atlantic OCS would relieve some of this upward pressure, leading to higher oil consumption and somewhat lower prices from those that would have prevailed after the increase in demand from population growth but before the increase in Atlantic OCS production. Hence, the displacement estimated in this study assumes only one factor affecting market prices would change: Atlantic OCS production. Any additional exogenous changes affecting supply conditions arising, for example, from technological innovations, or demand factors originating from population or income growth, are a separate matter.

The associated changes in greenhouse gas emissions are directly proportional to these changes in net oil and gas consumption. In addition to greenhouse gas emissions, offshore crude oil production would incur costs associated with the risks of oil spills.

Finally, there are costs associated with other environmental impacts from oil and gas production, such as land and water contamination from onshore spills and well blowouts.

As the analysis above demonstrates, higher oil and gas production will increase value added, employment, and tax revenues. These gains, however, will come at the price of additional greenhouse gas and other air emissions. The size of these emissions will depend upon how oil and natural gas markets adjust to higher regional production. These emissions also can be reduced by technological innovations in the production and consumption of oil and natural gas. These reductions, however, are not estimated in this study. Hence, the estimates of environmental impact costs presented below could be over-estimated.

Given the market responses reported in the literature, which are described in Appendix A, roughly 50 percent of the increase in regional oil production offsets production elsewhere in the world. Figure 5 summarizes the gross and net increases in world crude oil production for the high production scenario for regional production. Under the this scenario, the gross increase in world production is 388,000 barrels per day in 2035 but after accounting for reduced production elsewhere, the net increase in world production and consumption is 196,000 barrels per day (see Figure 5).

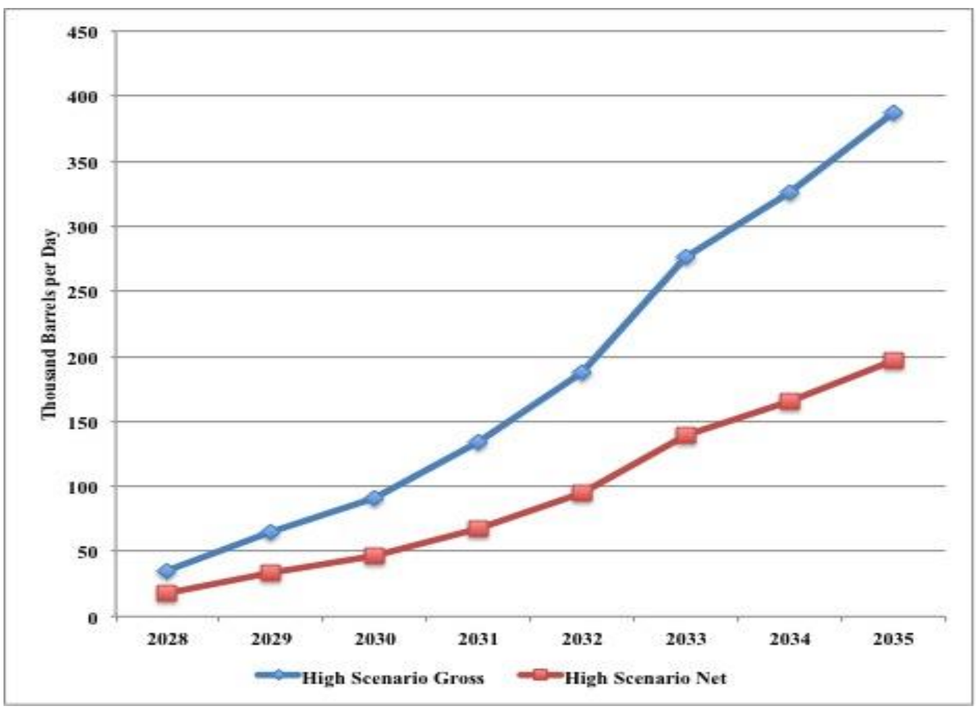

Figure 5: Gross and Net Increases in World Oil Consumption, 2028-2035

Corresponding with these increases in net world oil consumption are higher greenhouse gas emissions. Assuming 21.2 pounds of CO_2 per gallon of crude oil consumed plus another 20 percent to reflect emissions during the production, refining, and transportation of petroleum products, results in the estimates for greenhouse gas emissions from higher regional oil production illustrated in Figure 6.

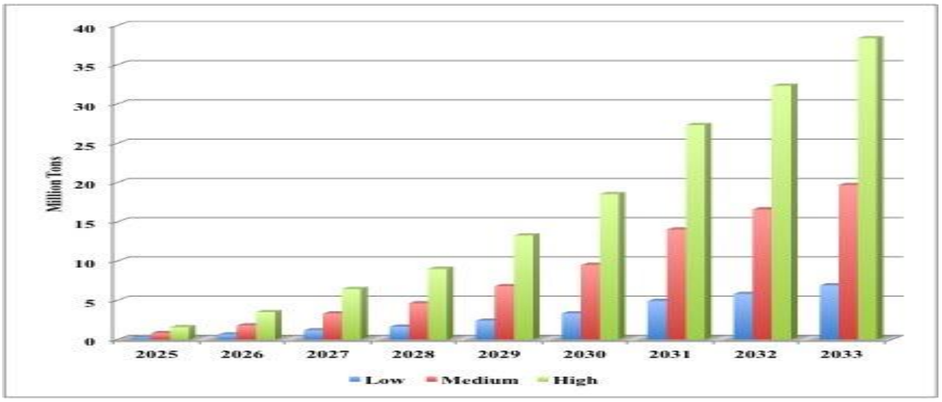

Figure 6: Greenhouse Gas Emissions from Oil Production, 2028-2035

Under the low production scenario, greenhouse gas emissions reach 7 million tons by 2035. Under the medium scenario, emissions increase with production to 20 million tons in the last year of the forecast horizon. The high production scenario shows an increase in emissions of 38 million tons during 2035. While these increases may seem large in an absolute sense, they are only between 0.13 and 0.72 percent of the 5.3 billion tons of total U.S. carbon dioxide emissions from energy consumption during 2012.

To place an economic value on these emissions and, thereby, compare the environmental impacts with the economic benefits, estimates of the costs of greenhouse gas and other air emissions are required. For this, the Interagency Working Group on the Social Cost of Carbon (2013) provides the latest estimates that are summarized in the Figure 7. Under the low cost scenario, greenhouse gas emission costs slowly rise from $13 in 2015 to $21 per ton in 2035. The medium scenario has emission costs rising from $42 in 2015 to $63 per ton in 2035. Finally, under the high cost scenario in which significant damages occur from global climate change, emission costs are nearly $120 per ton in 2015 and rise to nearly $195 per ton by 2035.

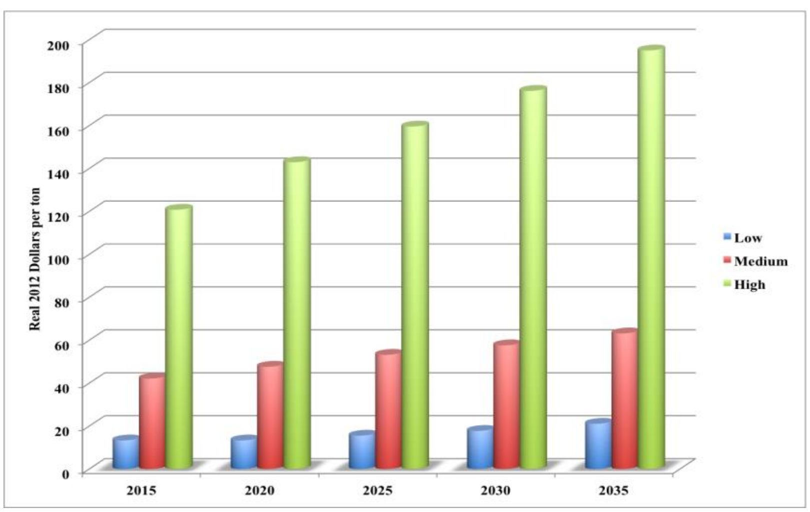

Figure 7: Carbon Price Scenarios

These emission costs per ton in Figure 7 and the estimated net emissions reported in Figure 6 allow an estimation of the value of the environmental impacts from higher crude oil production. A similar set of calculations for carbon and other air emissions associated with incremental natural gas production is undertaken. The study by Jaramillo (2007) provides estimates of the life cycle of greenhouse gas emissions in the natural gas industry. Given the widespread concern about methane leaks during natural gas production, this study includes these emissions based upon a recent study by Allen et al. (2013).

Table 6: Environmental Impacts of Oil & Gas Development in Study Region

	Million 2012 Dollars					
	Air Emissions			Expected Value of Oil Spills		
Year	Low	Medium	High	Low	Medium	High
2025	0.0	0.0	0.0	0.0	0.0	0.0
2026	0.4	3.6	20.9	0.1	0.1	1.5
2027	5.1	48.6	286.3	1.0	4.7	19.8
2028	11.7	110.8	655.4	2.3	10.7	44.4
2029	22.3	208.4	1,237.6	4.3	19.7	82.1
2030	31.9	295.9	1,763.6	6.0	27.6	114.8
2031	48.7	444.2	2,653.8	8.8	40.6	169.1
2032	70.6	632.6	3,787.9	12.3	56.7	236.2
2033	107.7	950.5	5,704.5	18.1	83.6	348.3
2034	131.7	1145.0	6,885.5	21.4	98.9	412.0
2035	161.5	1384.1	8,340.6	25.5	117.5	489.2

Another significant concern with expanding offshore oil production involves oil spills. In fact, the present-day moratorium on offshore drilling off the eastern and western coasts of the United States originates with the 1968 well blowout off the Santa Barbara coast. This policy has become a fixture of U.S. energy policy despite the likelihood of billions of barrels of recoverable oil under continental coastal waters.

Unlike the environmental impacts from additional oil and natural gas consumption, the environmental impacts of oil spills are inherently uncertain in nature. In other words, they can occur but with low frequency. The environmental impacts, therefore, should be considered with some element of risk. The best measure of occurrence of oil spills in this situation is the expected value or the most likely outcome given the distribution of possible outcomes.

Using records of actual oil spills, Anderson et al. (2012) find that 32,329 barrels of oil are spilled for every billion barrels produced. Harper et al. (1995) find that offshore and onshore costs of cleanup are between $30,000 and $107,000 per barrel spilled. Using these values for the three production scenarios provides estimates of the expected value of oil spill costs from higher oil production from the study area.

The three different carbon price and oil spill cost damage estimates combined with the three production scenarios creates nine possible combinations of outcomes. In the interest of parsimony, this study selects three outcomes that bracket all possible outcomes: low production & low valuation scenarios, medium production and medium valuations scenarios, and high production and high valuation scenarios. The results appear in Table 6.

As Table 6 illustrates, the environmental costs are dominated by those associated with air emissions. Under the low production scenario with low valuation of emissions, greenhouse gas emissions cost $162 million in 2035. Recall these estimates are for carbon prices that vary between $13 and $22 per ton. Current carbon prices in the European Union are roughly $7 per ton. In contrast, oil spill costs under the same scenario are slightly over $25 million. With higher carbon prices between $42 and $63 per ton, greenhouse costs rise to $1.38 billion in 2035. Exxon-Mobil and British Petroleum use carbon prices of roughly $50 per ton for internal planning purposes. With higher valuations of oil spills, these costs rise to over $117 million in the medium scenario (see column 5, Table 6). Finally, under rather extraordinary carbon prices of between $121 and $195 per ton, air emission costs are $8.3 billion. Much higher unit damages associated with oil spills drive those costs to over $489 million in 2035 (see Table 6).

3.4 Net Costs and Benefits

The natural question at this juncture is how do the benefits of offshore oil and gas development compare with the environmental costs. Incremental value added or the net contribution to the economy is a good measure of the economic benefits. To simplify the comparison, the discounted present value of incremental value added and environmental costs are computed from 2017 to 2035, assuming a 3% discount rate to account for the time value of money and compensate for the effects of inflation. A summary of the total regional benefits and costs appears in Figure 8.

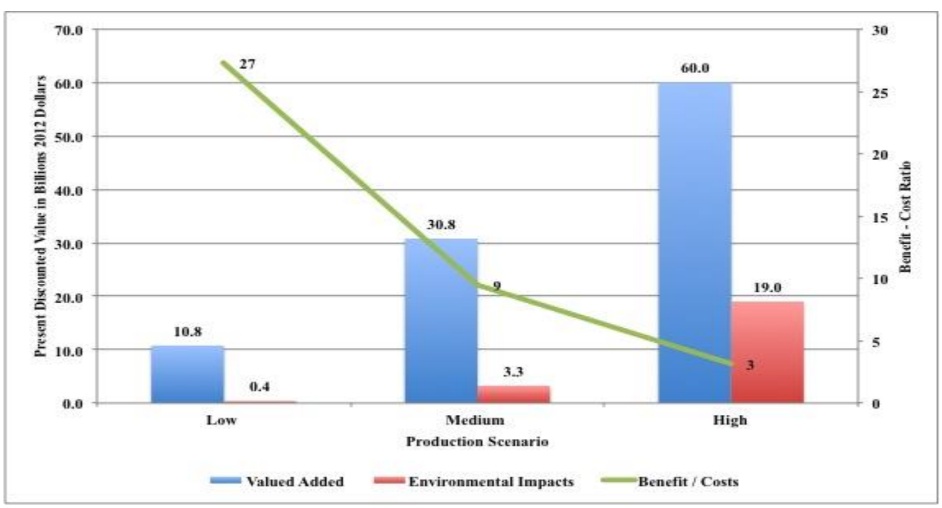

Figure 8: Valued Added, Environmental Impacts, and Benefit-Cost Ratios

Under the low production scenario, the region gains $10.8 billion in value added over the entire period and incurs a $395 million cost related to environmental impacts. The implied benefit-cost ratio of 27 for this scenario is so high because environmental valuations are so low. The medium scenario with carbon prices between $42 and $63 has economic benefits of nearly $31 billion and environmental costs of $3.3 billion. While environmental costs are considerably higher for this scenario, the economic benefits exceed costs by nine-to-one. With extraordinarily high carbon prices approaching $200 per ton under the high production and high valuation scenarios the benefit-cost ratio declines from the medium scenario but even so benefits exceed cost by a ratio of three-to-one. Hence, across all three scenarios, benefits substantially exceed costs. These findings suggest that allowing lease sales in the Atlantic OCS study area would incur costs but the benefits are far larger, which implies a net increase in social welfare.

4. Impacts by State

The economic, fiscal, and environmental impacts by state are now discussed. These impacts are proportional to the level of production in each state estimated by Quest Offshore (2013). The following sections provide discussion of the state-by-state disaggregation of the total regional impacts discussed in section three. The overall finding remains the same - benefits substantially exceed costs even under extreme assumptions for environmental valuations.

Of the six states in the study area, three – North Carolina, South Carolina and Virginia – have the largest development potential. These three states benefit the most due to long coastlines and promising reserve potential. Another favorable factor facilitating development is port facilities and infrastructure, which likely will be revitalized with oil and gas development. Like the downstream manufacturing revival stimulated by the shale gas and tight oil boom, offshore oil and gas development would add to this renaissance and will likely induce investments in port facilities supporting the construction and deployment of offshore production platforms. The potential economic impacts of these investments will be assessed below.

4.1 North Carolina

Among the six states in the study area, North Carolina is likely to experience the highest level of oil and gas development spending given its relatively long coastline and promising offshore reserves. The three scenarios for oil and gas investment outlays and operating expenses are described below in Table 7. Spending levels gradually ramp up to between $15 million and $85 million from the low to high scenarios in 2020. After 2020, spending increases dramatically ranging from $146 to $811 million in 2025, $601 million to $3.3 billion in 2030, and from $755 and $4.2 billion in 2035. Cumulative real investment spending and operating expenditures to support oil and gas operations offshore North Carolina from 2017 to 2035 are $6.1, $17.5, and $34.0 billion across the low, medium, and high production scenarios, respectively.

These investments eventually make North Carolina a significant producer of crude oil and natural gas. Under the medium scenario, crude oil production reaches 70.3 thousand barrels per day in 2035. Production exceeds 137,000barrels per day in 2035 under the high production scenario. Natural gas production is between 192 and 1,070 million cubic feet per day in 2035 (see Table 8). North Carolina currently consumes 997 million cubic feet per day, so the high production scenario would supply in excess of current state natural gas consumption. The corresponding increases in value added and employment for these spending scenarios are presented in Table 9. By 2035, value added or gross regional product (GRP) in the state is from $2.7 to $5.2 billion higher under the medium and high production scenarios. The corresponding gains in employment are between 36,000 and 72,000.

Table 7: Spending Scenarios for Oil and Gas Development in North Carolina

	Million 2012 Dollars		
Year	Low	Medium	High
2017	3	9	18
2018	9	26	51
2019	11	31	60
2020	15	44	85
2021	21	61	120
2022	30	87	170
2023	64	184	359
2024	126	359	699
2025	146	416	811
2026	275	785	1,529
2027	360	1,030	2,006
2028	447	1,277	2,488
2029	538	1,536	2,992
2030	601	1,718	3,347
2031	673	1,921	3,744
2032	667	1,906	3,714
2033	666	1,903	3,708
2034	696	1,988	3,874
2035	755	2,156	4,201

The significant fiscal benefits are estimated in Table 10. For the medium and high production scenarios, annual state revenues from leases and royalties are $588 million and $1.1 billion in 2035. State and local tax revenues increase between $137 and $267 million for these two scenarios. So in total, annual state revenues increase between $726 million and $1.4 billion in 2035, which are significant contributions to a total state budget that in recent years has been close to $50 billion.

The environmental impacts are presented in Table 11. Under the medium production scenario, environmental impacts from air emissions amount to $489 million and the expected value of oil spills is $41.5 million. Hence, total environmental impacts in 2035 are $530.9 million, which is less than 20 percent of the gains in value added (2,692 x 20% = $538 million).

Table 8: Oil and Gas Production Scenarios in North Carolina

	Crude Oil – thousand bbl / day			Natural Gas – million cf / day		
Year	Low	Medium	High	Low	Medium	High
2025	0.0	0.0	0.0	0.0	0.0	0.0
2026	0.1	0.2	0.3	0.7	2.1	4.1
2027	0.9	2.7	5.2	12.7	36.3	70.7
2028	2.3	6.5	12.6	31.7	90.5	176.4
2029	4.3	12.4	24.1	56.3	160.9	313.5
2030	6.2	17.7	34.5	77.5	221.4	431.3
2031	9.2	26.4	51.4	112.7	321.9	627.1
2032	12.8	36.6	71.3	141.1	403.2	785.5
2033	18.1	51.7	100.7	166.7	476.3	928.0
2034	21.1	60.2	117.3	176.8	505.0	983.9
2035	24.6	70.3	137.1	192.3	549.2	1,070.1

Table 9: Economic Impacts in North Carolina

	GRP - Million 2012 Dollars			Full Time Equivalent Jobs		
Year	Low	Medium	High	Low	Medium	High
2017	4	12	23	52	148	289
2018	13	37	72	166	473	922
2019	15	42	82	188	538	1,047
2020	23	67	130	297	849	1,654
2021	32	90	176	469	1,340	2,610
2022	42	121	235	635	1,815	3,536
2023	80	228	445	1,113	3,180	6,196
2024	134	383	747	1,992	5,690	11,086
2025	167	478	931	2,434	6,954	13,549
2026	301	859	1,675	4,508	12,876	25,089
2027	397	1,135	2,212	5,855	16,725	32,587
2028	502	1,435	2,795	7,446	21,269	41,442
2029	610	1,743	3,397	8,996	25,696	50,066
2030	682	1,947	3,794	9,684	27,663	53,899
2031	773	2,209	4,304	11,052	31,569	61,511
2032	791	2,261	4,404	11,270	32,191	62,723
2033	827	2,362	4,602	11,495	32,834	63,975
2034	855	2,442	4,758	11,506	32,867	64,039
2035	942	2,692	5,245	12,798	36,557	71,230

Table 10: Fiscal Impacts in North Carolina

	Million 2012 Dollars					
	Oil & Gas Leases & Royalties			State & Local Taxes		
Year	Low	Medium	High	Low	Medium	High
2017	0.0	0.0	0.0	0.2	0.6	1.2
2018	1.4	4.0	7.7	0.7	1.9	3.7
2019	1.6	4.6	9.0	0.8	2.2	4.2
2020	6.2	17.8	34.7	1.2	3.4	6.6
2021	6.5	18.5	36.0	1.6	4.6	9.0
2022	6.9	19.8	38.6	2.2	6.2	12.0
2023	6.7	19.1	37.3	4.1	11.6	22.7
2024	6.9	19.8	38.6	6.8	19.5	38.1
2025	6.5	18.5	36.0	8.5	24.3	47.4
2026	7.3	20.9	40.8	15.3	43.8	85.4
2027	18.7	53.3	103.9	20.3	57.9	112.8
2028	30.9	88.3	172.1	25.6	73.1	142.5
2029	46.7	133.4	260.0	31.1	88.9	173.2
2030	64.4	183.9	358.4	34.7	99.3	193.4
2031	86.4	246.9	481.1	39.4	112.6	219.4
2032	112.2	320.4	624.3	40.3	115.2	224.5
2033	148.5	424.3	826.6	42.2	120.4	234.6
2034	170.3	486.4	947.7	43.6	124.5	242.5
2035	206.0	588.5	1,146.7	48.0	137.2	267.4

Table 11: Environmental Impacts in North Carolina

	Million 2012 Dollars					
	Air Emissions			Expected Value of Oil Spills		
Year	Low	Medium	High	Low	Medium	High
2025	0.0	0.0	0.0	0.0	0.0	0.0
2026	0.1	0.9	5.4	0.0	0.0	0.4
2027	1.7	16.3	95.8	0.3	1.6	6.6
2028	4.2	39.8	235.7	0.8	3.8	16.0
2029	8.2	77.3	458.8	1.6	7.3	30.5
2030	12.1	112.2	668.4	2.3	10.4	43.5
2031	18.7	170.4	1,017.7	3.4	15.6	64.8
2032	26.9	241.1	1,443.9	4.7	21.6	90.0
2033	39.3	346.7	2,080.6	6.6	30.5	127.0
2034	47.3	411.4	2,474.3	7.7	35.6	148.1
2035	57.1	489.4	2,949.0	9.0	41.5	173.0

North Carolina is well positioned to grow the necessary supply-chain related industries to support oil and gas development. The state is home to General Electric in Durham that manufactures turbines; ABB Power in Cary, Raleigh, and Huntsville and Siemens in Wendell that supply power transmission equipment to the oil and gas industry; and DSM Dyneema in Stanley that provides mooring and lifting ropes for the offshore drilling industry. These companies would likely expand their operations in North Carolina if an offshore oil and gas industry develops in the state.

North Carolina's ports are considered a key strategic asset for manufacturing firms located in the state by facilitating access to raw materials and for shipping final products to national and international markets. North Carolina's port infrastructure at Moorhead City and Wilmington will also play a prominent role in the development of an offshore oil and gas industry. According to Findley et al (2011) these ports generated $7.5 billion in value added, over $500 million in tax revenues, and more than 65,000 jobs by enabling the movement of goods and cargo throughout the state.

Using the industry multipliers implicit in the results from Quest Offshore (2013), offshore oil and gas development would support roughly 1,800 full-time equivalent jobs in North Carolina ports during the year 2035. Additional gains are possible if, as is likely the case, offshore oil and gas development induces capital investments in port facilities. These gains could be significant. For example, Richardson (2012) finds that a $100 million capital investment in ports in Louisiana generates 1,740 jobs. While some portion of expansion projects occur over a finite length of time from a year to three years, ports continually invest to expand capacity and improve the quality of service. These on-going investment activities also are likely to be stimulated by offshore oil and gas investment.

4.2 South Carolina

The second highest level of spending on offshore oil and gas development is projected to be in South Carolina. Under the Quest Offshore (2013) baseline, or the high production scenario, capital investment spending and operating expenses for offshore oil and gas development reach more than $2.7 billion in 2035. The medium scenario has production spending at $1.4 billion in 2035 (see Table 12). Cumulative real investment spending and operating expenditures to support oil and gas operations offshore South Carolina from 2017 to 2035 are $3.6, $10.3, and $20 billion across the low, medium, and high production scenarios. These investments bring crude oil production to more than 131 thousand barrels per day and natural gas production to nearly 1.0 billion cubic feet per day in 2035, more than consumption of 669 million cubic per day during 2012 (see Table 13) under the high production scenario. Like North Carolina, South Carolina could join the ranks of states that are significant producers of oil and gas.

The structure of South Carolina's economy is likely to foster the development of oilfield equipment manufacturing. South Carolina is home to several automobile-manufacturing companies, including BMW, Honda, and Daimler. Boeing also has manufacturing plants in the state. In addition, Bosch has manufacturing plants producing for supplies to the energy industry. The South Carolina manufacturing workforce would be an attractive factor in firm decisions to build or expand capacity within the state to provide oil field supplies and support services.

This investment spending and the outlays for operating expenses to sustain production generate sizable economic output gains with value added rising by $3.5 billion and employment gains of more than 45,000 full-time equivalent jobs in 2035 for the high production scenario. A less successful outcome described in the medium production scenario still has rather significant output and employment gains (see Table 14) with over $1.8 billion in additional value added and over 23,000 jobs.

Table 12: Spending Scenarios for Oil and Gas Development in South Carolina

	Million 2012 Dollars		
Year	Low	Medium	High
2017	3	7	14
2018	8	22	42
2019	9	26	50
2020	12	36	69
2021	14	40	77
2022	19	55	107
2023	38	108	211
2024	58	164	320
2025	82	234	456
2026	135	385	749
2027	184	526	1,026
2028	232	663	1,292
2029	286	818	1,594
2030	346	987	1,924
2031	390	1,113	2,169
2032	409	1,169	2,277
2033	431	1,230	2,397
2034	451	1,288	2,510
2035	490	1,400	2,727

The fiscal impacts are presented in Table 15. With a focus on what the state fiscal picture would look like after nearly a decade of offshore production, the State of South Carolina would be receiving $1.1 billion in oil and gas lease and royalty revenue and another $163 million in state and local tax revenues for a total of $1.3 billion dollars during 2035 under the high production scenario. Another way to view this result is that if the federal government had allowed lease sales back in 2004, the South Carolina budget would have more than $1.3 billion in extra revenue today. The medium production scenario estimates a revenue increase of $564 million from oil and gas sources and $84 million from general state and local taxes for a total revenue gain of $648 million.

Like North Carolina, greenhouse gas emissions and the expected costs of potential oil spills offset some of these gains. For the medium scenario, greenhouse gas emission costs are $469 million and oil spills costs are $40 million in 2035 for a total of $509 million, considerably less than the $1.8 billion in incremental value added. While the

Table 13: Oil and Gas Production Scenarios in South Carolina

	Crude Oil – thousand bbl / day			Natural Gas – million cf / day		
Year	Low	Medium	High	Low	Medium	High
2025	0.0	0.0	0.0	0.0	0.0	0.0
2026	0.1	0.2	0.3	0.8	2.2	4.2
2027	0.9	2.5	4.8	11.7	33.5	65.3
2028	2.0	5.8	11.4	28.5	81.3	158.5
2029	3.8	10.8	21.0	49.1	140.3	273.3
2030	5.4	15.3	29.8	67.1	191.6	373.3
2031	7.9	22.4	43.7	95.9	273.9	533.6
2032	11.2	32.0	62.4	123.4	352.5	686.9
2033	17.1	48.8	95.2	157.6	450.2	877.2
2034	20.1	57.5	112.0	168.7	482.0	939.1
2035	23.6	67.4	131.3	184.2	526.2	1,025.3

Table 14: Economic Impacts in South Carolina

	GRP - Million 2012 Dollars			Full Time Equivalent Jobs		
Year	Low	Medium	High	Low	Medium	High
2017	3	9	18	39	111	217
2018	12	36	69	154	440	857
2019	14	40	78	170	485	945
2020	20	56	109	234	669	1,303
2021	22	63	122	296	846	1,648
2022	28	80	156	375	1,070	2,085
2023	48	136	265	602	1,720	3,351
2024	66	189	368	852	2,433	4,740
2025	93	265	517	1,218	3,479	6,778
2026	148	423	824	1,999	5,711	11,128
2027	204	584	1,137	2,750	7,854	15,303
2028	261	747	1,455	3,553	10,150	19,776
2029	326	930	1,812	4,371	12,486	24,328
2030	389	1,111	2,166	5,107	14,588	28,423
2031	447	1,276	2,486	5,892	16,830	32,791
2032	483	1,381	2,690	6,415	18,325	35,705
2033	537	1,534	2,988	7,067	20,186	39,331
2034	567	1,621	3,158	7,353	21,002	40,922
2035	630	1,801	3,509	8,214	23,462	45,714

Table 15: Fiscal Impacts in South Carolina

	Million 2012 Dollars					
	Oil & Gas Leases & Royalties			State & Local Taxes		
Year	Low	Medium	High	Low	Medium	High
2017	0.0	0.0	0.0	0.2	0.4	0.8
2018	4.4	12.5	24.4	0.6	1.7	3.2
2019	4.6	13.2	25.7	0.7	1.9	3.7
2020	6.7	19.1	37.3	0.9	2.6	5.1
2021	6.9	19.8	38.6	1.0	2.9	5.7
2022	7.4	21.1	41.1	1.3	3.7	7.2
2023	7.2	20.4	39.8	2.2	6.3	12.3
2024	7.2	20.4	39.8	3.1	8.8	17.1
2025	6.9	19.8	38.6	4.3	12.4	24.1
2026	7.6	21.6	42.1	6.9	19.7	38.4
2027	17.2	49.2	95.9	9.5	27.2	53.0
2028	27.8	79.4	154.7	12.2	34.8	67.8
2029	40.7	116.3	226.7	15.2	43.3	84.4
2030	55.7	159.2	310.2	18.1	51.8	100.9
2031	73.5	210.1	409.3	20.8	59.4	115.8
2032	98.1	280.2	545.9	22.5	64.3	125.3
2033	140.4	401.0	781.4	25.0	71.4	139.2
2034	162.5	464.2	904.5	26.4	75.5	147.1
2035	197.4	563.9	1,098.8	29.4	83.9	163.4

Table 16: Environmental Impacts in South Carolina

	Million 2012 Dollars					
	Air Emissions			Expected Value of Oil Spills		
Year	Low	Medium	High	Low	Medium	High
2025	0.0	0.0	0.0	0.0	0.0	0.0
2026	0.1	0.9	5.6	0.0	0.0	0.4
2027	1.6	15.0	88.5	0.3	1.5	6.1
2028	3.8	35.8	211.7	0.7	3.4	14.3
2029	7.2	67.4	400.0	1.4	6.4	26.5
2030	10.5	97.1	578.4	2.0	9.0	37.7
2031	15.9	144.9	865.9	2.9	13.2	55.2
2032	23.5	210.9	1,262.6	4.1	18.9	78.7
2033	37.1	327.7	1,966.6	6.2	28.8	120.1
2034	45.2	392.7	2,361.5	7.4	33.9	141.3
2035	54.7	468.9	2,825.7	8.6	39.8	165.7

margin between benefits and costs narrows under the high production and valuation scenario, incremental environmental costs at $2.8 billion remain less than the change in valued added of $3.5 billion. This scenario, however, is for extremely high carbon prices.

South Carolina has two major ports that would likely play a prominent role in offshore oil and gas production. The Port of Charleston is one of the busiest and most efficient ports in the nation. The Port of Georgetown, a dedicated break bulk and bulk facility, handles large volumes of cement, metals, and petroleum coke. Using the multipliers for economic impacts on ports implies that offshore oil and gas development would create more than 1,174 jobs for these ports in 2035 under the high production scenario. Additional employment would be created as these ports invest in new capacity and handle larger volumes of equipment and materials for an offshore oil and gas industry.

4.3 Virginia

The third highest level of spending on oil and gas development in the study region is Virginia. As Table 17 below indicates, oil and gas investment and operating outlays in Virginia during 2025 reach between $82 and $455 million from the low to high production scenarios. By 2035, spending levels are $404 million, $1.2, and $2.2 billion in the low, medium, and high production scenarios respectively.

Table 17: Spending Scenarios for Oil and Gas Development in Virginia

	Million 2012 Dollars		
Year	Low	Medium	High
2017	2	5	9
2018	5	14	27
2019	6	16	32
2020	8	24	46
2021	11	32	63
2022	16	47	91
2023	40	113	221
2024	58	166	324
2025	82	234	455
2026	145	416	810
2027	187	534	1,041
2028	237	677	1,319
2029	290	828	1,613
2030	322	919	1,790
2031	359	1,026	1,999
2032	357	1,021	1,990
2033	375	1,071	2,086
2034	378	1,078	2,101
2035	404	1,155	2,250

Cumulative real investment spending and operating expenditures to support oil and gas operations offshore Virginia from 2017 to 2035 are $3.3, $9.4, and $18.3 billion across the low, medium, and high production scenarios, which can be obtained by summing the numbers appearing in the last three columns of Table 17.

Virginia's promising oil and gas resource base encourage these investments. As a result, crude oil approaches 63 thousand barrels per day by 2035 under the high production scenario (see Table 18). Natural gas production reaches 491 million cubic feet per day in 2035 under the same scenario (see Table 18). As a larger, more populous state, Virginia consumes approximately 1.1 billion cubic feet per day, so potential offshore production could comprise slightly less than half of statewide consumption, which nevertheless could provide a valuable hedge against the vagaries of regional natural gas production and transportation.

Table 18: Oil and Gas Production Scenarios in Virginia

	Crude Oil – thousand bbl / day			Natural Gas – million cf / day		
Year	Low	Medium	High	Low	Medium	High
2025	0.0	0.0	0.0	0.0	0.0	0.0
2026	0.0	0.1	0.2	0.4	1.1	2.2
2027	0.5	1.3	2.6	6.2	17.7	34.4
2028	1.1	3.1	6.0	15.1	43.1	84.1
2029	2.1	5.9	11.5	26.9	76.7	149.5
2030	2.9	8.4	16.3	36.7	104.7	204.1
2031	4.4	12.6	24.5	53.9	153.8	299.7
2032	6.0	17.2	33.6	66.4	189.8	369.8
2033	8.3	23.7	46.2	76.5	218.4	425.5
2034	9.7	27.7	53.9	81.3	232.2	452.4
2035	11.3	32.3	62.9	88.2	251.9	490.9

The economic impacts associated with these spending levels are presented in Table 19. Like the previous two states, the economic impacts build over time as spending and production increases. By 2025, under the medium production scenario, gross regional product or value added rises by $270 million and employment rises by over 3,100 jobs, $1.1 billion in 2030 and more than 12,000 jobs, and $1.4 billion and more than 16,000 jobs in 2035. The high production scenario generates incremental value added of $526 million and an additional 6,000 jobs in 2025, $2.1 billion and over 23,000 jobs in 2030, and $2.8 billion and more than 32,000 jobs in 2035.

The estimated impacts on the Virginia state budget are presented in Table 20. In the last year of the forecast horizon, Virginia collects between $94 and $526 million in oil and gas lease and royalty revenues and from $21 to $119 million in state and local taxes. These two sources combined could augment state and local revenues from $115 to $645 million dollars depending upon how much oil and gas are eventually discovered. If Virginia oil and gas leases were sold 18 years ago, Virginia's current state budget could be improved by these amounts, thus illustrating the impact of delays in offshore lease sales.

Table 19: Economic Impacts in Virginia

	GRP - Million 2012 Dollars			Full Time Equivalent Jobs		
Year	Low	Medium	High	Low	Medium	High
2017	2	6	12	21	59	116
2018	6	18	36	67	191	373
2019	8	22	42	78	222	432
2020	12	36	69	131	373	727
2021	16	47	91	202	576	1,122
2022	22	64	125	276	788	1,536
2023	49	140	272	547	1,561	3,042
2024	65	185	360	746	2,131	4,151
2025	94	270	526	1,087	3,105	6,051
2026	163	466	909	1,921	5,486	10,689
2027	211	602	1,173	2,465	7,041	13,719
2028	271	773	1,506	3,191	9,115	17,761
2029	334	953	1,857	3,946	11,272	21,963
2030	370	1,057	2,059	4,248	12,134	23,643
2031	418	1,194	2,326	4,862	13,889	27,062
2032	425	1,214	2,365	4,991	14,256	27,776
2033	460	1,313	2,558	5,360	15,309	29,829
2034	464	1,325	2,581	5,265	15,038	29,301
2035	503	1,436	2,798	5,768	16,477	32,104

The associated environmental impacts appear in Table 21. Under the medium production and valuation scenario, air emission environmental impacts are $224.5 million while expected oil spill costs are $19.1 million in 2035. Hence, total environmental impact costs are $243.6 million, considerably below the $1.4 and $2.8 billion of gross state product generated in that year under the medium and high production scenarios respectively.

Virginia has the deepest port on the East Coast and the largest dry docks in the U.S. at Newport News Shipbuilding. The state is also home to major offshore industry supplier Oceaneering in Chesapeake, Bauer Compressors in Norfolk, PaR Marine, and Strongwell in Bristol that produces materials for floating production units. These companies and their supporting infrastructure would be valuable assets for supporting the development of oil and gas drilling off the Virginia coast. Based upon the employment estimates by industry developed by Quest Offshore (2013), the higher production

Table 20: Fiscal Impacts in Virginia

	Million 2012 Dollars					
	Oil & Gas Leases & Royalties			State & Local Taxes		
Year	Low	Medium	High	Low	Medium	High
2017	0.0	0.0	0.0	0.1	0.3	0.5
2018	0.7	2.0	3.9	0.3	0.8	1.5
2019	0.7	2.0	3.9	0.3	0.9	1.8
2020	3.5	9.9	19.3	0.5	1.5	2.9
2021	3.5	9.9	19.3	0.7	2.0	3.9
2022	3.7	10.6	20.6	1.0	2.7	5.3
2023	3.7	10.6	20.6	2.1	5.9	11.6
2024	3.7	10.6	20.6	2.7	7.8	15.3
2025	3.7	10.6	20.6	4.0	11.4	22.3
2026	4.0	11.4	22.3	6.9	19.8	38.5
2027	9.1	26.0	50.6	8.9	25.5	49.8
2028	14.7	42.1	82.0	11.5	32.8	63.9
2029	22.3	63.6	124.0	14.2	40.4	78.8
2030	30.5	87.0	169.6	15.7	44.8	87.3
2031	41.3	118.0	229.9	17.7	50.6	98.7
2032	52.8	150.8	293.9	18.0	51.5	100.3
2033	68.1	194.5	379.0	19.5	55.7	108.5
2034	78.3	223.6	435.7	19.7	56.2	109.5
2035	94.5	270.0	526.1	21.3	60.9	118.7

Table 21: Environmental Impacts in Virginia

	Million 2012 Dollars					
	Air Emissions			Expected Value of Oil Spills		
Year	Low	Medium	High	Low	Medium	High
2025	0.0	0.0	0.0	0.0	0.0	0.0
2026	0.1	0.5	2.9	0.0	0.0	0.2
2027	0.8	7.9	46.7	0.2	0.8	3.2
2028	2.0	19.0	112.3	0.4	1.8	7.6
2029	3.9	36.9	218.8	0.8	3.5	14.5
2030	5.7	53.1	316.2	1.1	4.9	20.6
2031	8.9	81.4	486.3	1.6	7.4	31.0
2032	12.7	113.5	679.6	2.2	10.2	42.4
2033	18.0	159.0	954.0	3.0	14.0	58.3
2034	21.8	189.2	1,137.6	3.5	16.3	68.1
2035	26.2	224.5	1,352.9	4.1	19.1	79.4

scenario would support over 824 jobs in the Ports of Chesapeake and Norfolk. Given existing infrastructure, offshore oil and gas drilling could attract additional investment in refineries and other energy facilities making Virginia's port an energy center for the East Coast, similar to the role Houston plays in Gulf of Mexico oil and gas development.

4.4 Georgia

Given the relatively short coastline, Georgia is projected to have the smallest level of oil and gas spending of the six states in the study region. The three scenarios for oil and gas investment outlays and operating expenses are described below in Table 22. Spending levels gradually ramp up to between $1 million and $8 million from the low to high scenarios in 2020. After 2020, spending increases dramatically, ranging from $12 to $64 million in 2025, $46 million to $258 million in 2030, and from $60 and $334 million in 2035. Cumulative real investment spending and operating expenditures to support oil and gas operations offshore Georgia from 2017 to 2035 are $479 million, and $1.4 and $2.7 billion across the low, medium, and high production scenarios.

Table 22: Spending Scenarios for Oil and Gas Development in Georgia

	Million 2012 Dollars		
Year	Low	Medium	High
2017	0	1	1
2018	1	2	4
2019	1	3	5
2020	1	4	8
2021	2	5	10
2022	3	7	14
2023	5	15	30
2024	9	25	49
2025	12	33	64
2026	21	59	116
2027	27	77	149
2028	34	97	189
2029	42	119	233
2030	46	133	258
2031	52	150	292
2032	53	152	296
2033	55	158	307
2034	55	158	308
2035	60	172	334

These investments eventually produce modest amounts of crude oil and natural gas. Under the medium scenario, crude oil production reaches 14,000 barrels per day in 2035. Production exceeds 27,000 barrels per day in 2035 under the high production scenario. Natural gas production is between 38 and 212 million cubic feet per day in 2035 (see Table 23).

Table 23: Oil and Gas Production Scenarios in Georgia

	Crude Oil – thousand bbl / day			Natural Gas – million cf / day		
Year	Low	Medium	High	Low	Medium	High
2025	0.0	0.0	0.0	0.0	0.0	0.0
2026	0.0	0.1	0.2	0.4	1.3	2.5
2027	0.2	0.7	1.3	3.1	8.8	17.2
2028	0.3	1.0	1.9	4.7	13.4	26.2
2029	0.4	1.2	2.4	5.5	15.7	30.5
2030	0.5	1.4	2.7	6.0	17.0	33.2
2031	0.5	1.4	2.7	5.9	16.9	32.9
2032	0.9	2.5	4.9	9.7	27.8	54.2
2033	2.7	7.7	15.0	24.8	70.8	138.0
2034	3.6	10.2	19.8	29.9	85.3	166.2
2035	4.9	13.9	27.1	38.0	108.6	211.6

Table 24: Economic Impacts in Georgia

	GRP - Million 2012 Dollars			Full Time Equivalent Jobs		
Year	Low	Medium	High	Low	Medium	High
2017	0	1	3	4	13	24
2018	4	12	23	51	146	285
2019	5	13	26	56	159	310
2020	5	15	28	61	175	341
2021	6	17	33	77	220	429
2022	7	20	40	93	266	519
2023	10	30	58	133	380	740
2024	13	38	73	177	507	987
2025	17	49	96	227	649	1,265
2026	28	79	154	377	1,077	2,097
2027	34	98	191	461	1,317	2,567
2028	43	122	238	575	1,642	3,200
2029	52	149	290	699	1,995	3,888
2030	57	162	315	719	2,053	4,001
2031	63	181	352	809	2,311	4,503
2032	67	190	370	840	2,398	4,673
2033	81	230	449	995	2,841	5,535
2034	85	242	472	1,002	2,863	5,578
2035	98	281	548	1,175	3,356	6,539

Georgia currently consumes 1.6 billion cubic feet per day, so even the high production scenario would supply less than 10 percent of current state natural gas consumption.

The corresponding increases in value added and employment for these spending scenarios are presented in Table 24. By 2035, value added in the state ranges from $281 to $548 million higher under the medium and high production scenarios. The corresponding gains in employment are between 3,300 and 6,500 jobs in 2035 for these two scenarios.

The environmental impacts are presented in Table 25. Under the medium production scenario, environmental impacts from air emissions amount to $96.8 million and the expected value of oil spills is $8.2 million. Hence, total environmental impacts in 2035 are $105 million, which is only 37 and 19 percent of the gains in value added for the medium and high production scenarios respectively.

Table 25: Environmental Impacts in Georgia in Million 2012 Dollars

	Air Emissions			Expected Value of Oil Spills		
Year	Low	Medium	High	Low	Medium	High
2025	0.0	0.0	0.0	0.0	0.0	0.0
2026	0.1	0.6	3.3	0.0	0.0	0.2
2027	0.4	4.0	23.3	0.1	0.4	1.6
2028	0.6	5.9	35.0	0.1	0.6	2.4
2029	0.8	7.5	44.7	0.2	0.7	3.0
2030	0.9	8.6	51.4	0.2	0.8	3.3
2031	1.0	8.9	53.4	0.2	0.8	3.4
2032	1.9	16.6	99.7	0.3	1.5	6.2
2033	5.8	51.5	309.3	1.0	4.5	18.9
2034	8.0	69.5	417.9	1.3	6.0	25.0
2035	11.3	96.8	583.1	1.8	8.2	34.2

The fiscal benefits are estimated in Table 26. For the medium and high production scenarios, state revenues from leases and royalties are $116.4 and $226.7 million in 2035. State and local tax revenues increase between $11 and $22 million for the medium and high production scenarios. So in total for these two scenarios, state revenues increase between $127.4 and $248.7 million in 2035.

The ports of Savannah and Brunswick provide more than adequate marine traffic capacity for the prospective oil and gas development envisioned in this study for offshore Georgia. Using the industry multipliers implicit in the results from Quest Offshore (2013), offshore oil and gas development would support roughly 168 full-time equivalent jobs in Georgia ports during the year 2035. Additional gains are possible if, as is likely the case, offshore oil and gas development induces capital investments in port facilities. While some portion of expansion projects occur over a finite length of time from a year to three years, ports continually invest to expand capacity and improve the quality of service. These on-going investment activities also are likely to be stimulated by offshore oil and gas investment.

Table 26: Fiscal Impacts in Georgia

	Million 2012 Dollars					
	Oil & Gas Leases & Royalties			State & Local Taxes		
Year	Low	Medium	High	Low	Medium	High
2017	0.0	0.0	0.0	0.0	0.1	0.1
2018	4.2	11.9	23.1	0.2	0.5	0.9
2019	4.4	12.5	24.4	0.2	0.5	1.0
2020	4.4	12.5	24.4	0.2	0.6	1.1
2021	4.6	13.2	25.7	0.2	0.7	1.3
2022	4.8	13.9	27.0	0.3	0.8	1.6
2023	4.6	13.2	25.7	0.4	1.2	2.3
2024	4.6	13.2	25.7	0.5	1.5	2.9
2025	4.6	13.2	25.7	0.7	1.9	3.8
2026	4.4	12.7	24.7	1.1	3.1	6.0
2027	4.5	13.0	25.3	1.3	3.9	7.5
2028	4.6	13.1	25.6	1.7	4.8	9.3
2029	4.6	13.0	25.3	2.0	5.8	11.4
2030	5.0	14.1	27.6	2.2	6.3	12.4
2031	4.5	13.0	25.2	2.5	7.1	13.8
2032	7.7	22.1	43.1	2.6	7.5	14.5
2033	22.1	63.1	122.9	3.2	9.0	17.6
2034	28.8	82.1	160.1	3.3	9.5	18.5
2035	40.7	116.4	226.7	3.9	11.0	21.5

4.5 Maryland

The fourth highest level of spending on offshore oil and gas development is projected to be in Maryland. Under the high production scenario, capital investment spending and operating expenses for offshore oil and gas development reach more than $685 million in 2035. The medium scenario has production spending at $352 million in 2035 (see Table 27). Cumulative real investment spending and operating expenditures to support oil and gas operations offshore Maryland from 2017 to 2035 are $961 million and $2.7, and $5.3 billion across the low, medium, and high production scenarios.

The investments under the high production scenario result in crude oil production of 15,000barrels per day and natural gas production of more than 117 million cubic feet per day in 2035 (see Table 28). Economic output increases with value added rising by $703 million and employment gains of more than 9,000 full-time equivalent jobs in 2035 for the high production scenario. A less successful outcome described in the medium productions scenario has over $361 million in additional value added and over 4,600 jobs (see Table 29).

Table 27: Spending Scenarios for Oil and Gas Development in Maryland

	Million 2012 Dollars		
Year	Low	Medium	High
2017	1	2	4
2018	2	5	10
2019	2	6	12
2020	3	9	17
2021	4	11	22
2022	6	16	32
2023	11	32	62
2024	16	45	87
2025	22	64	125
2026	39	113	220
2027	51	144	281
2028	65	185	361
2029	83	237	461
2030	91	260	506
2031	105	300	585
2032	108	309	603
2033	115	330	643
2034	114	325	634
2035	123	352	685

The fiscal impacts are presented in Table 30. The medium production scenario estimates a revenue increase of $64 million from oil and gas sources and $20 million from general state and local taxes for a total revenue gain of $84 million in 2035. Under the high production scenario, oil and gas lease and royalty income is $128 million in 2035 while state and local taxes increase by $39 million. Hence, state reviews increase by $167 million in 2035 under the high production scenario.

The economic costs of air emissions and the expected costs of potential oil spills offset some of these gains. For the medium scenario, greenhouse gas emission costs are nearly $54 million and oil spills costs are $4.6 million in 2035 for a total of $58.6 million (see Table 31), considerably less than the $361 and $703 million in incremental value added under the medium and high production scenarios. This margin closes with higher valuation costs under the high production and valuation scenario. In this case, air emission costs rise to $323 million and oil spills cost could be as high as $19 million for a total environmental impact cost of $342. So even under rather extreme values for air emissions and oil spill costs, total environmental costs or damages are less than the economic benefits.

Table 28: Oil and Gas Production Scenarios in Maryland

	Crude Oil – thousand bbl / day			Natural Gas – million cf / day		
Year	Low	Medium	High	Low	Medium	High
2025	0.0	0.0	0.0	0.0	0.0	0.0
2026	0.0	0.1	0.1	0.3	0.8	1.5
2027	0.2	0.4	0.9	2.1	6.0	11.8
2028	0.3	0.9	1.7	4.2	12.0	23.4
2029	0.6	1.6	3.1	7.2	20.6	40.2
2030	0.7	2.0	4.0	8.9	25.5	49.8
2031	1.1	3.1	6.0	13.1	37.3	72.8
2032	1.4	3.9	7.6	15.1	43.0	83.8
2033	1.8	5.0	9.8	16.2	46.2	90.0
2034	2.1	6.1	12.0	18.0	51.4	100.2
2035	2.7	7.7	15.0	21.1	60.2	117.3

Table 29: Economic Impacts in Maryland

	GRP - Million 2012 Dollars			Full Time Equivalent Jobs		
Year	Low	Medium	High	Low	Medium	High
2017	1	2	4	8	24	46
2018	3	8	15	47	133	260
2019	3	9	18	52	148	288
2020	5	15	30	65	187	364
2021	6	18	35	70	199	387
2022	8	23	46	88	251	489
2023	12	33	65	132	376	732
2024	15	42	81	156	447	870
2025	21	60	117	240	686	1,336
2026	35	100	195	365	1,043	2,033
2027	44	127	247	481	1,374	2,678
2028	57	164	319	612	1,749	3,408
2029	76	217	424	781	2,230	4,344
2030	83	237	461	928	2,651	5,165
2031	99	283	550	1,081	3,087	6,014
2032	106	302	588	1,198	3,423	6,669
2033	116	331	645	1,362	3,890	7,579
2034	114	326	636	1,446	4,132	8,050
2035	126	361	703	1,632	4,662	9,084

Table 30: Fiscal Impacts in Maryland

	Million 2012 Dollars					
	Oil & Gas Leases & Royalties			State & Local Taxes		
Year	Low	Medium	High	Low	Medium	High
2017	0.0	0.0	0.0	0.0	0.1	0.2
2018	0.9	2.6	5.1	0.2	0.4	0.8
2019	0.9	2.6	5.1	0.2	0.5	1.0
2020	2.3	6.6	12.9	0.3	0.8	1.6
2021	2.5	7.3	14.1	0.3	1.0	1.9
2022	2.8	7.9	15.4	0.5	1.3	2.5
2023	2.5	7.3	14.1	0.6	1.8	3.6
2024	2.8	7.9	15.4	0.8	2.3	4.5
2025	2.5	7.3	14.1	1.1	3.3	6.4
2026	2.7	7.6	14.8	1.9	5.5	10.7
2027	3.1	8.9	17.3	2.4	6.9	13.5
2028	4.1	11.7	22.9	3.1	9.0	17.5
2029	6.0	17.1	33.3	4.2	11.9	23.2
2030	7.4	21.2	41.4	4.5	13.0	25.3
2031	10.0	28.6	55.8	5.4	15.5	30.2
2032	12.0	34.2	66.6	5.8	16.6	32.3
2033	14.4	41.2	80.2	6.4	18.1	35.4
2034	17.3	49.6	96.5	6.3	17.9	34.9
2035	22.6	64.5	125.7	6.9	19.8	38.5

Table 31: Environmental Impacts in Maryland in Million 2012 Dollars

	Million 2012 Dollars					
	Air Emissions			Expected Value of Oil Spills		
Year	Low	Medium	High	Low	Medium	High
2025	0.0	0.0	0.0	0.0	0.0	0.0
2026	0.0	0.3	2.0	0.0	0.0	0.1
2027	0.3	2.7	16.0	0.1	0.3	1.1
2028	0.6	5.3	31.3	0.1	0.5	2.1
2029	1.1	9.9	58.8	0.2	0.9	3.9
2030	1.4	12.9	77.1	0.3	1.2	5.0
2031	2.2	19.8	118.1	0.4	1.8	7.5
2032	2.9	25.7	154.1	0.5	2.3	9.6
2033	3.8	33.6	201.9	0.6	3.0	12.3
2034	4.8	41.9	252.1	0.8	3.6	15.1
2035	6.3	53.6	323.2	1.0	4.6	19.0

4.6 Delaware

The spending for offshore oil and gas investments and operating expenditures scenarios for Delaware are reported in Table 32. Spending in 2035 ranges from a low of $86 to a high of $481 million. Crude oil output ranges from 2.6 to 14.2 thousand barrels per day while natural gas production could range between 20 and 111.2 million cubic feet per day in 2035 (see Table 33). Incremental value added could rise from $108 to $599 million in 2035 (see Table 34). Likewise, gains in full-time equivalent jobs are estimated to be between 1,100 and 6,200 (see Table 34). Oil and gas lease and royalty payments could generate between $21.4 and $119.2 million. State and local taxes also increase, ranging from a $6 to $33.4 million gain. Finally, environmental impacts from air emissions are between $5.9 and $307 million and expected oil spill costs are from $0.9 to $18 million. Like the other states, the gains in value added exceed the environmental impacts.

Table 32: Spending Scenarios for Oil and Gas Development in Delaware

	Million 2012 Dollars		
Year	Low	Medium	High
2017	0	1	3
2018	2	5	9
2019	2	5	10
2020	3	8	15
2021	3	7	14
2022	3	9	18
2023	5	15	30
2024	7	21	41
2025	10	30	58
2026	16	46	89
2027	22	64	125
2028	29	82	159
2029	40	114	222
2030	51	145	283
2031	61	173	338
2032	67	192	374
2033	74	211	411
2034	80	228	445
2035	86	247	481

Currently, the Delaware City Refinery is processing over 200 thousand barrels of crude per day and is accepting a greater share of Bakken crude oil from North Dakota. The potential output from the offshore fields developed in the study area could displace some of this Bakken crude oil and, thereby, mitigate some of the problems associated with its transport and delivery.

Table 33: Oil and Gas Production Scenarios in Delaware

	Crude Oil – thousand bbl / day			Natural Gas – million cf / day		
Year	Low	Medium	High	Low	Medium	High
2025	0.0	0.0	0.0	0.0	0.0	0.0
2026	0.0	0.1	0.1	0.2	0.7	1.4
2027	0.2	0.4	0.9	2.1	6.0	11.8
2028	0.3	0.8	1.6	4.0	11.3	22.0
2029	0.5	1.5	3.0	6.9	19.8	38.6
2030	0.7	1.9	3.7	8.3	23.8	46.5
2031	1.0	2.9	5.7	12.5	35.6	69.3
2032	1.3	3.8	7.3	14.5	41.3	80.5
2033	1.7	4.8	9.3	15.4	44.0	85.7
2034	2.1	5.9	11.5	17.3	49.4	96.3
2035	2.6	7.3	14.2	20.0	57.1	111.2

Table 34: Economic Impacts in Delaware

	GRP - Million 2012 Dollars			Full Time Equivalent Jobs		
Year	Low	Medium	High	Low	Medium	High
2017	1	2	4	5	15	28
2018	3	7	14	22	64	125
2019	3	8	15	25	72	140
2020	5	13	26	44	125	243
2021	4	13	24	44	127	247
2022	5	15	30	53	150	293
2023	7	20	40	67	191	373
2024	9	26	51	83	238	464
2025	12	34	66	105	301	586
2026	17	49	96	158	452	880
2027	24	70	136	230	656	1,278
2028	31	89	174	293	838	1,632
2029	44	126	245	423	1,209	2,356
2030	57	162	315	544	1,553	3,027
2031	69	197	384	676	1,931	3,762
2032	78	222	433	773	2,209	4,304
2033	88	251	488	887	2,535	4,939
2034	97	278	542	997	2,848	5,548
2035	108	307	599	1,106	3,160	6,156

Table 35: Fiscal Impacts in Delaware

	Million 2012 Dollars					
	Oil & Gas Leases & Royalties			State & Local Taxes		
Year	Low	Medium	High	Low	Medium	High
2017	0.0	0.0	0.0	0.0	0.1	0.2
2018	0.9	2.6	5.1	0.1	0.4	0.8
2019	0.9	2.6	5.1	0.2	0.4	0.9
2020	2.3	6.6	12.9	0.3	0.7	1.4
2021	2.3	6.6	12.9	0.2	0.7	1.4
2022	2.5	7.3	14.1	0.3	0.8	1.6
2023	2.5	7.3	14.1	0.4	1.1	2.2
2024	2.5	7.3	14.1	0.5	1.5	2.9
2025	2.5	7.3	14.1	0.7	1.9	3.7
2026	2.4	7.0	13.6	1.0	2.8	5.4
2027	3.1	8.9	17.3	1.4	3.9	7.6
2028	3.9	11.0	21.5	1.7	5.0	9.7
2029	5.7	16.4	32.0	2.5	7.0	13.7
2030	6.9	19.8	38.6	3.2	9.0	17.6
2031	9.6	27.3	53.2	3.9	11.0	21.4
2032	11.5	32.8	64.0	4.3	12.4	24.2
2033	13.7	39.2	76.3	4.9	14.0	27.3
2034	16.7	47.6	92.7	5.4	15.5	30.3
2035	21.4	61.2	119.2	6.0	17.2	33.4

Table 36: Environmental Impacts in Delaware

	Million 2012 Dollars					
	Air Emissions			Expected Value of Oil Spills		
Year	Low	Medium	High	Low	Medium	High
2025	0.0	0.0	0.0	0.0	0.0	0.0
2026	0.0	0.3	1.8	0.0	0.0	0.1
2027	0.3	2.7	16.0	0.1	0.3	1.1
2028	0.5	5.0	29.5	0.1	0.5	2.0
2029	1.0	9.5	56.5	0.2	0.9	3.7
2030	1.3	12.1	72.0	0.2	1.1	4.7
2031	2.1	18.8	112.4	0.4	1.7	7.2
2032	2.8	24.7	148.0	0.5	2.2	9.2
2033	3.6	32.0	192.1	0.6	2.8	11.7
2034	4.6	40.3	242.1	0.8	3.5	14.5
2035	5.9	50.9	306.6	0.9	4.3	18.0

4. Conclusions

To summarize and compare the impacts across states, the present discounted value of the streams of value added, tax revenues, and environmental impacts are computed assuming a 3 percent discount rate. The present discounted value of cumulative gross domestic product or value added is plotted below in Figure 9. The ranking of the states is clear, with North Carolina, South Carolina, and Virginia the largest winners if Atlantic offshore oil and gas production is allowed. Under the high production scenario, North Carolina could realize over $24.5 billion in economic output, $4.3 billion in additional tax revenues (see Figure 10), and on average almost 30,000 additional jobs each year over the period 2017 to 2035 (see Figure 11). South Carolina also may experience significant economic benefits with over $14.6 billion in additional economic output, $3.5 billion in more tax revenues, and over 16,000 jobs per year. Likewise, Virginia is a close third with over $13.3 billion in economic product, $2 billion in tax revenues, and over 13,000 more jobs annually over the forecast period.

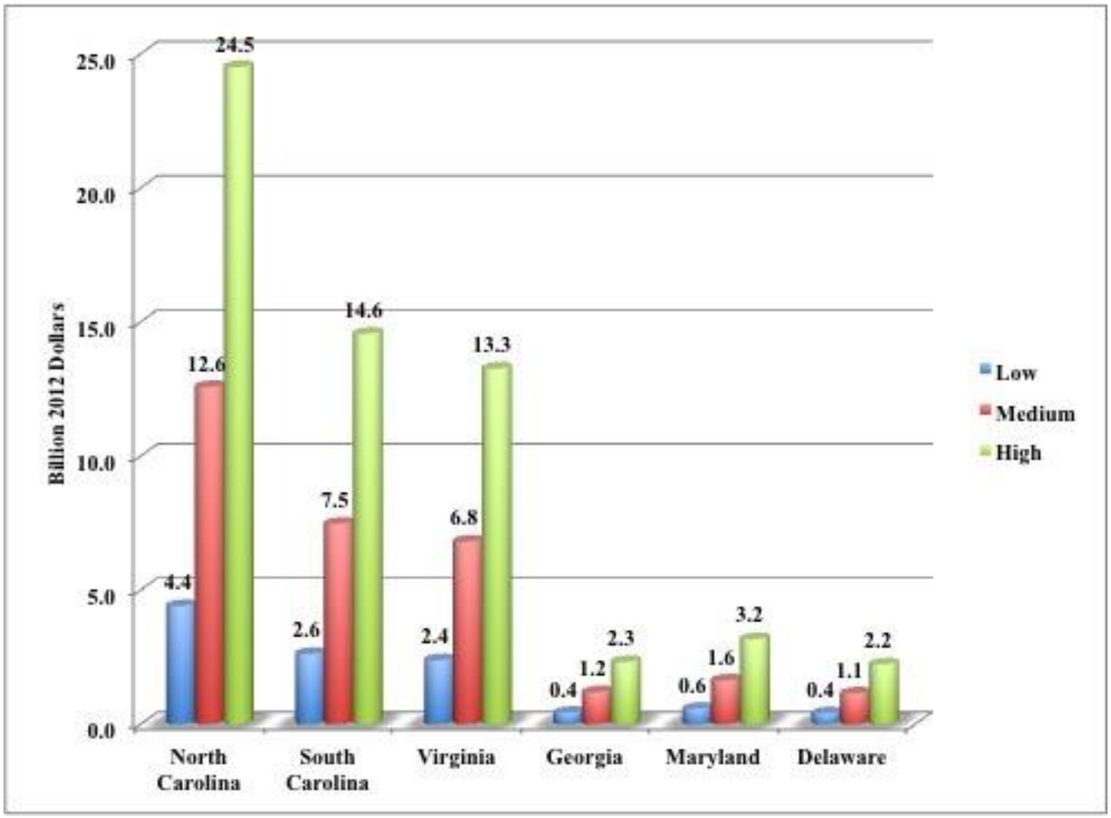

Figure 9: Present Discounted Value of Cumulative Value Added by State

These gains, however, should be tempered by the economic costs associated with the environmental impacts summarized by state in Figure 12. These impacts, however, are considerably smaller than the gains in value added. For example, even for the high production scenario with very high estimates for carbon prices, upwards of $195 per ton, environmental costs are $5.4 billion for North Carolina compared with $19 billion in incremental value added, implying a benefit-cost ratio of approximately 4. The benefit ratios are much higher under the medium scenario for environmental valuations of damages. This result suggests that the economic benefits of offshore oil and gas development are likely to far exceed the economic value of environmental damages.

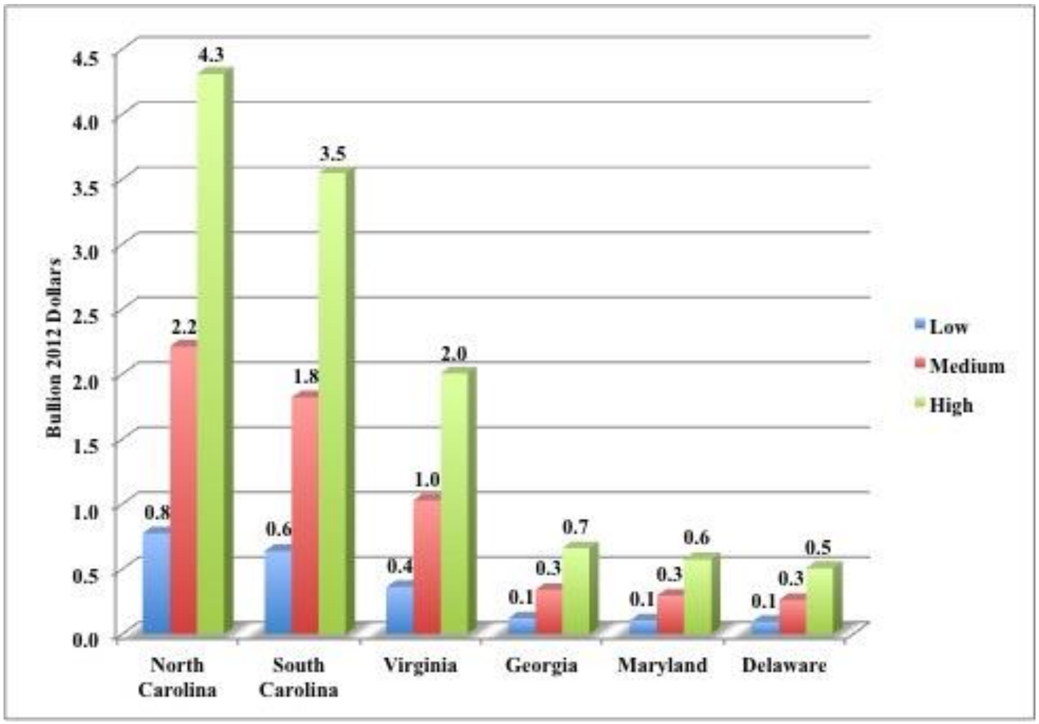

Figure 10: Present Discounted Value of Cumulative Tax Revenues by State

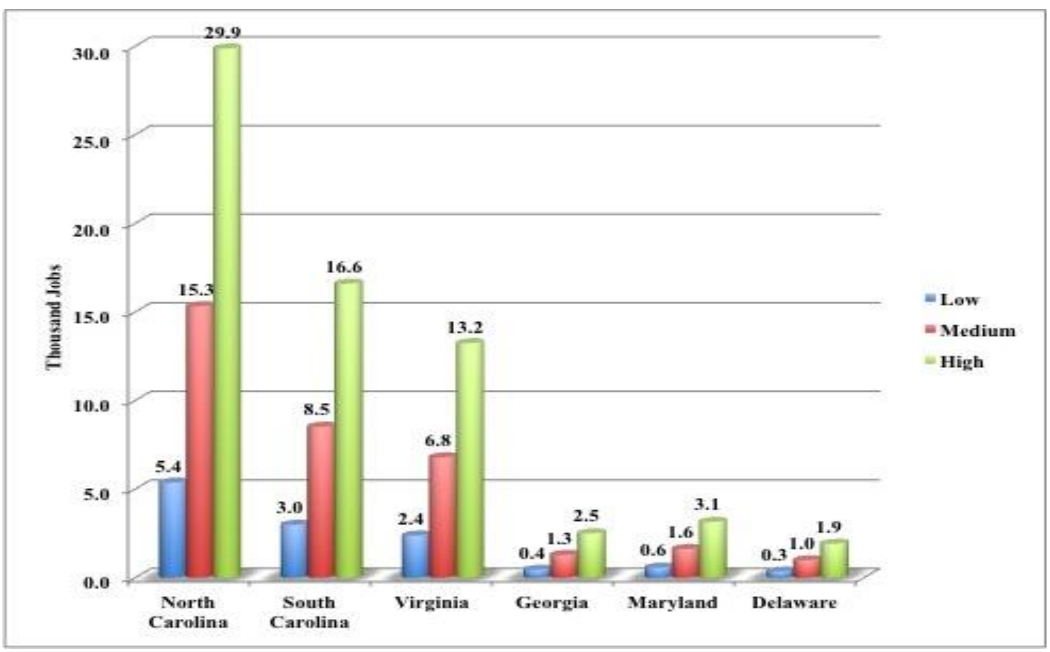

Figure 11: Average Annual Employment Gains by State

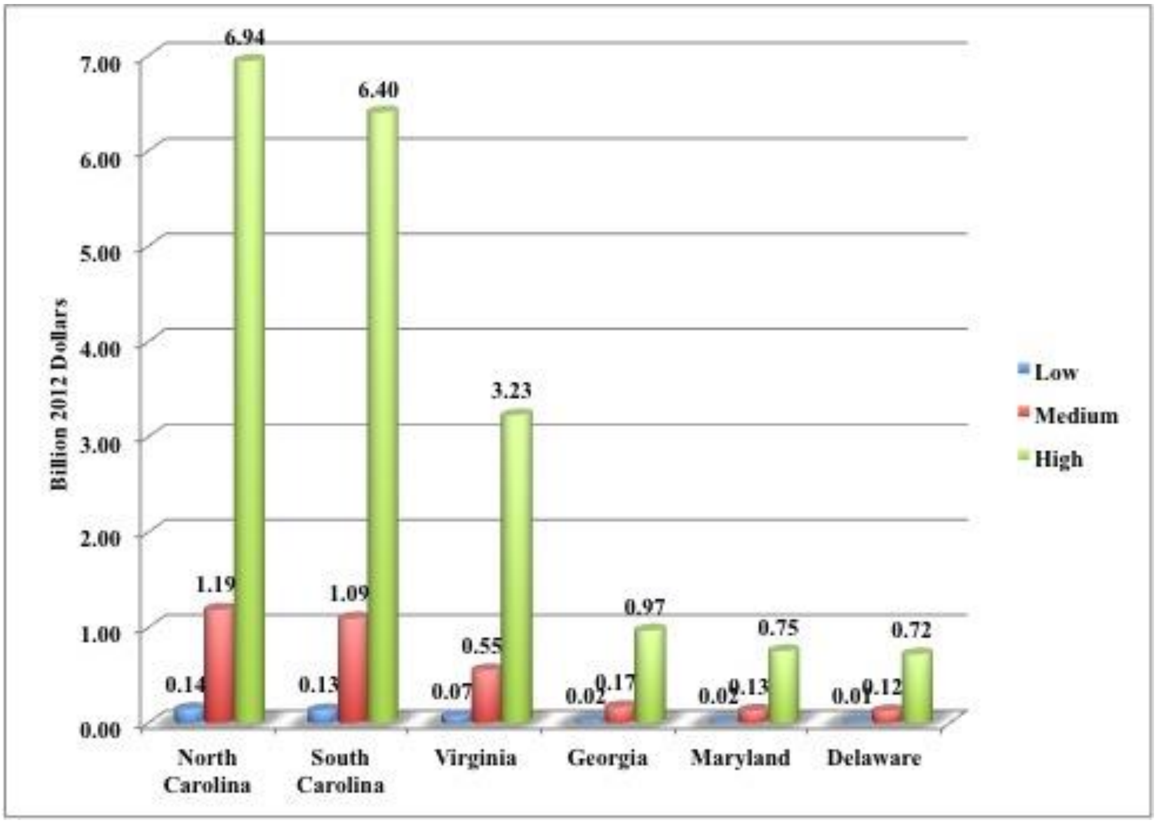

Figure 12: Present Discounted Value of Environmental Impacts by State

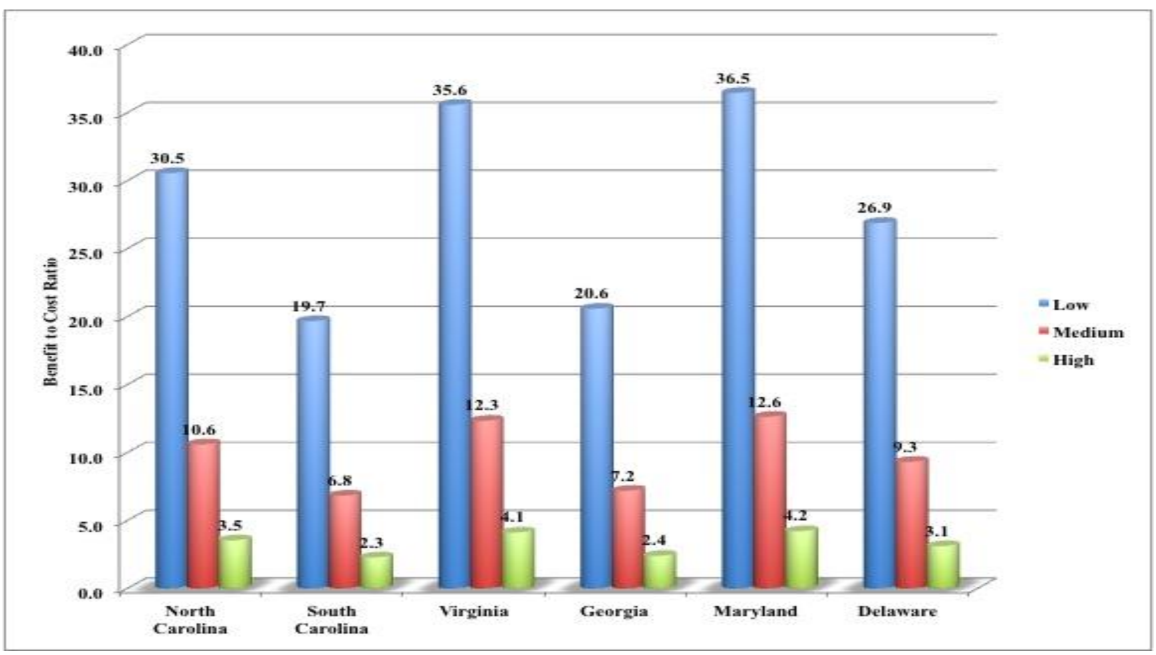

Figure 13: Benefit Cost Ratios by State

Appendix A: Analysis of Supply and Demand Adjustments

Consider the equilibrium condition for the crude oil or natural gas market:

$$Q_d = Q_o + Q_c, \tag{1}$$

where Q_d is the total demand for crude oil or natural gas, Q_c is production of crude oil or natural gas from the study region, and Q_o is crude oil or natural gas supply from other regions.

Recognizing that each quantity in (1) is a function of price, taking the total differential of (1) and re-arranging terms yields:

$$\frac{dQ_d}{dP}\frac{dP}{dQ_c} = \frac{dQ_o}{dP}\frac{dP}{dQ_c} + 1 \tag{2}$$

Factoring equation (2) and transforming to express in terms of elasticities provides:

$$\begin{aligned}
&\frac{dP}{PdQ_c}\left[Q_d\left(\frac{P}{Q_d}\frac{dQ_d}{dP}\right) - Q_o\left(\frac{P}{Q_o}\frac{dQ_o}{dP}\right)\right] = 1 \\
&\frac{d\ln P}{dQ_c}\left[Q_d\left(\frac{d\ln Q_d}{d\ln P}\right) - Q_o\left(\frac{d\ln Q_o}{d\ln P}\right)\right] = 1 \\
&d\ln P = \frac{dQ_c}{\left[Q_d e_d - Q_o e_o\right]}
\end{aligned} \tag{3}$$

where e_d is the elasticity of total market demand and e_o is the elasticity of supply from other regions. The change in incremental demand is given by:

$$dQ_d = Q_d d\ln P. \tag{4}$$

The change in production from other regions can be computed as follows:

$$dQ_o = dQ_d - dQ_c. \tag{5}$$

The elasticities of supply and demand for natural gas and crude oil are determined based upon a review of the literature. The crude oil supply elasticity is 0.58 based upon a survey conducted by Dahl and Dugan (1996). The elasticity of crude oil demand is -0.58, which is an average of long-run price elasticities of demand reported by Hamilton (2009). The natural gas price elasticity of demand is -0.236, which is a sector weighted average of demand elasticities estimated following the model specifications developed by Considine et al. (2011b). The natural gas supply elasticity is 0.345, which is computed based upon a comparison of simulations from the National Energy Modeling System developed by the Energy Information Administration described by Considine (2013).

As an illustration of these calculations, consider the high production scenario for crude oil. The base world oil consumption forecast is from the Annual Energy Outlook for 2013. Demand for oil outside the study region is determined by subtracting base regional oil production assuming a 3 percent depletion rate plus the incremental change for each scenario from total world consumption projected by EIA. The percentage change in demand is computed using equations (4). Production outside the region is computed using equation (5).

An example of the results appear below in Table A1 indicating that the 390 thousand barrels per day of additional oil production from the region in 2035 under the high production scenario would reduce world prices by 0.3 percent, which would increase world consumption by 200 thousand barrels per day and reduce production outside California by 190 thousand barrels per day.

Table A1: Oil Market Adjustments under the High Production Scenario

	Percentage Change		Oil Use - mmbd		Supply Changes - mmbd	
Year	Price	Demand	World	Change	Region	Other
2017	0.00	0.00	93.3	0.00	0.00	0.00
2018	0.00	0.00	94.5	0.00	0.00	0.00
2019	0.00	0.00	95.5	0.00	0.00	0.00
2020	0.00	0.00	96.4	0.00	0.00	0.00
2021	0.00	0.00	97.1	0.00	0.00	0.00
2022	0.00	0.00	97.6	0.00	0.00	0.00
2023	0.00	0.00	98.2	0.00	0.00	0.00
2024	0.00	0.00	99.1	0.00	0.00	0.00
2025	0.00	0.00	100.3	0.00	0.00	0.00
2026	0.00	0.00	101.7	0.00	0.00	0.00
2027	-0.01	0.01	103.2	0.01	0.02	-0.01
2028	-0.03	0.02	104.6	0.02	0.04	-0.02
2029	-0.05	0.03	105.8	0.03	0.07	-0.03
2030	-0.07	0.04	106.7	0.05	0.09	-0.04
2031	-0.11	0.06	107.4	0.07	0.13	-0.07
2032	-0.15	0.09	108.0	0.09	0.19	-0.09
2033	-0.22	0.13	108.6	0.14	0.28	-0.14
2034	-0.25	0.15	109.4	0.17	0.33	-0.16
2035	-0.30	0.18	110.2	0.20	0.39	-0.19

Appendix B: Value Added and Employment Multipliers

Table B1: Value Added Multipliers

	Dollars of Value Added per Dollar of Oil & Gas Spending					
Year	North Carolina	South Carolina	Virginia	Maryland	Georgia	Delaware
2017	1.29	1.27	1.29	1.00	2.00	1.50
2018	1.40	1.64	1.33	1.50	6.00	1.57
2019	1.36	1.56	1.32	1.56	5.00	1.50
2020	1.53	1.57	1.50	1.77	3.67	1.67
2021	1.47	1.58	1.45	1.61	3.25	1.73
2022	1.39	1.46	1.37	1.42	2.82	1.64
2023	1.24	1.26	1.23	1.05	1.96	1.35
2024	1.07	1.15	1.11	0.93	1.50	1.25
2025	1.15	1.13	1.16	0.93	1.50	1.13
2026	1.09	1.10	1.12	0.89	1.33	1.09
2027	1.10	1.11	1.13	0.88	1.28	1.09
2028	1.12	1.13	1.14	0.88	1.26	1.09
2029	1.14	1.14	1.15	0.92	1.25	1.10
2030	1.13	1.13	1.15	0.91	1.22	1.11
2031	1.15	1.15	1.16	0.94	1.21	1.14
2032	1.19	1.18	1.19	0.98	1.25	1.16
2033	1.24	1.25	1.23	1.00	1.46	1.19
2034	1.23	1.26	1.23	1.00	1.53	1.22
2035	1.25	1.29	1.24	1.03	1.64	1.25

Table B2: Employment Multipliers

Year	Jobs per Million Dollars of Oil and Gas Spending					
	North Carolina	South Carolina	Virginia	Maryland	Georgia	Delaware
2017	16.1	15.4	12.9	12.0	19.0	11.0
2018	17.9	20.2	13.8	25.3	74.0	13.9
2019	17.3	18.8	13.4	24.9	60.3	13.6
2020	19.5	18.8	15.7	21.8	44.2	15.8
2021	21.8	21.4	17.8	17.7	41.8	17.5
2022	20.8	19.5	16.8	15.2	36.7	16.3
2023	17.3	15.9	13.8	11.9	25.0	12.6
2024	15.9	14.8	12.8	10.0	20.2	11.3
2025	16.7	14.9	13.3	10.7	19.7	10.1
2026	16.4	14.9	13.2	9.3	18.1	9.9
2027	16.2	14.9	13.2	9.5	17.2	10.2
2028	16.7	15.3	13.5	9.4	16.9	10.2
2029	16.7	15.3	13.6	9.4	16.7	10.6
2030	16.1	14.8	13.2	10.2	15.5	10.7
2031	16.4	15.1	13.5	10.3	15.4	11.1
2032	16.9	15.7	14.0	11.1	15.8	11.5
2033	17.3	16.4	14.3	11.8	18.0	12.0
2034	16.5	16.3	13.9	12.7	18.1	12.5
2035	17.0	16.8	14.3	13.3	19.6	12.8

Appendix C: Environmental Impacts by Valuation Scenarios

Each scenario listed within each table corresponds with the low, medium, and high production scenarios. Each of the three tables below presents the estimated environmental impacts for low, medium, and high estimates of environmental valuations or charges per unit of emissions.

Table C1: Environmental Impacts for Low Valuations of Emissions

	Million 2012 Dollars					
	Air Emissions			Expected Value of Oil Spills		
Year	Low*	Medium	High	Low*	Medium	High
2025	0.0	0.0	0.0	0.0	0.0	0.0
2026	0.4	1.1	2.0	0.1	0.1	0.2
2027	5.1	14.5	28.2	1.0	2.9	2.9
2028	11.7	33.4	65.1	2.3	6.6	6.6
2029	22.3	63.5	123.8	4.3	12.2	12.6
2030	31.9	91.1	177.5	6.0	17.1	18.1
2031	48.7	139.1	271.3	8.8	25.1	27.7
2032	70.6	201.5	392.9	12.3	35.1	40.3
2033	107.7	307.6	600.1	18.1	51.8	61.7
2034	131.7	376.2	734.0	21.4	61.2	75.5
2035	161.5	461.4	900.4	25.5	72.7	92.8

* Used in columns 2 and 5 in Table 6 respectively.

Table C2: Environmental Impacts for Medium Valuations of Emissions

	Million 2012 Dollars					
	Air Emissions			Expected Value of Oil Spills		
Year	Low	Medium*	High	Low	Medium*	High
2025	0.0	0.0	0.0	0.0	0.0	0.0
2026	1.2	3.6	6.9	0.1	0.1	0.7
2027	17.0	48.6	94.7	1.7	4.7	9.3
2028	38.8	110.8	215.9	3.7	10.7	20.8
2029	73.0	208.4	406.2	6.9	19.7	38.4
2030	103.7	295.9	576.8	9.7	27.6	53.7
2031	155.6	444.2	866.1	14.2	40.6	79.1
2032	221.5	632.6	1,233.7	19.9	56.7	110.5
2033	332.8	950.5	1,854.3	29.3	83.6	163.0
2034	400.8	1,145.0	2,234.0	34.6	98.9	192.8
2035	484.5	1,384.1	2,701.2	41.1	117.5	228.9

* Used in columns 3 and 6 in Table 6 respectively.

Table C3: Environmental Impacts for High Valuations of Emissions

	Million 2012 Dollars					
	Air Emissions			Expected Value of Oil Spills		
Year	Low	Medium	High*	Low	Medium	High*
2025	0.0	0.0	0.0	0.0	0.0	0.0
2026	3.8	10.7	20.9	0.3	0.3	1.5
2027	51.5	147.0	286.3	3.6	10.1	19.8
2028	117.9	336.4	655.4	8.0	22.8	44.4
2029	222.5	635.1	1,237.6	14.8	42.2	82.1
2030	317.0	904.9	1,763.6	20.6	58.9	114.8
2031	476.8	1,361.2	2,653.8	30.4	86.8	169.1
2032	680.2	1,942.4	3,787.9	42.4	121.2	236.2
2033	1,023.8	2,924.2	5,704.5	62.6	178.8	348.3
2034	1,235.4	3,529.0	6,885.5	74.0	211.5	412.0
2035	1,495.9	4,273.8	8,340.6	87.9	251.1	489.2

* used in columns 4 and 7 in Table 6 respectively.

References

Allen, David, V.M Torres, J. Thomas, D. Sullivan, M. Harrison, A. Hendler, S. Herndon, C. Kolb, M. Fraser, A. Hill, B. Lamb (2013) "Measurements of Methane Emissions at Natural Gas Production Sites in the United States," Proceedings of the National Academies of Science, 110. 44, 17768-17773, http://www.pnas.org/content/110/44/17768.

Anderson C., M. Mayes, and R. LaBelle (2012) "Update of Occurrence rates for Offshore Oil Spills," U.S. Department of Interior, Bureau of Ocean Energy Management, http://www.boem.gov/uploadedFiles/BOEM/Environmental_Stewardship/Environmental_Assessment/Oil_Spill_Modeling/AndersonMayesLabelle2012.pdf.

Avalos, A. and D. Vera (2013) "The Petroleum Industry and the Monterey Shale: Current Economic Impact and the Economic Future of the San Joaquin Valley," California State University, Western State Petroleum Association, http://www.wspa.org/sites/default/files/uploads/The%20Petroleum%20Industry%20and%20the%20Monterey%20Shale%20-%20Fresno%20State%20Study.pdf, 38 pages.

Considine. T.J., R. Watson, N. Considine, and J. Martin (2013) "Environmental Regulation and Compliance in Marcellus Shale Gas Drilling," Environmental Geosciences, 20, 1, 1-16.

Considine, T.J. R. Watson, and N. Considine, (2011a) "The Economic Opportunities of Shale Energy Development," The Manhattan Institute, June 2011, http://www.manhattan-institute.org/pdf/eper_09.pdf, 28 pages.

Considine, T.J., R. Watson, and S. Blumsack (2011b) "The Economic Impacts of the Pennsylvania Marcellus Shale Natural Gas Play: An Update," Energy and Mineral Engineering, May 2010, 59 pages,

Dahl, C. and T. Duggan (1996) "U.S. Energy Product Supply Elasticities: A Survey and Application to the U.S. Oil Market," Resource and Energy Economics, Vol. 18, No. 3, 243-263.

Findley, D.J., C.M Cunningham, R.S. Foyle, A. Demers, G. List, J. Stone, K, Dobie, W. Hall, E. Hauser, W. Kemmsies, M. Smith (2011) "Economic Contribution of the North Carolina Ports," prepared for North Carolina State Ports Authority, 22 pages,http://www.csb.uncw.edu/people/hall/classes/ECN428/Economic%20Impact%20Project/Economic%20Contribution%20Final%20Report%20ITRE.pdf

Humphries, M. and R. Pirog (2012) "U.S. Offshore Oil and Gas Resources: Prospects and Processes," Congressional Research Service, http://assets.opencrs.com/rpts/R40645_20120210.pdf, 31 pages.

Hamilton, James (2009) "Understanding Crude Oil Prices," The Energy Journal, International Association for Energy Economics, vol. 30, No. 2, pages 179-206.

Harper, J. A. Godon, and A. Allen (1995) "Costs Associated with the Cleanup of Marine Oil Spills," http://ioscproceedings.org/doi/pdf/10.7901/2169-3358-1995-1-27.

Interagency Working Group on Social Cost of Carbon (2013) "United States Government Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis - Under Executive Order 12866," http://www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf

Jaramillo, Paulina (2007) "A Life Cycle Comparison of Coal and Natural Gas for Electricity Generation and the Production of Transportation Fuels, " Ph.D. Dissertation, Carnegie Mellon University.

Quest Offshore (2013) "The Economic Benefits of Increasing U.S. Access to Offshore Oil and Natural Gas Resources in the Atlantic," 125 pages, http://www.api.org/~/media/Files/Oil-and-Natural-Gas/Exploration/Offshore/Atlantic-OCS/Executive-Summary-Economic-Benefits-of-Increasing-US-Access-to-Atlantic-Offshore-Resources.pdf.

Richardson, J.A. (2012) "The Economic Impact of Ports of Louisiana," Ports Association of Louisiana, http://portsoflouisiana.org/wp-content/uploads/2012-final-report.pdf, 16 pages.

U.S. Energy Information Administration (2013) "Annual Energy Outlook for 2013," http://www.eia.gov/forecasts/aeo/pdf/0383(2013).pdf.