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Economic Analysis Methodology for the Five Year OCS Oil and Gas Leasing Program for 2012-2017

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Introduction

This paper describes the factors considered and the calculations behind the Net Benefits analysis found in part IV.C of the decision document for the 2012-2017 Proposed Final Program. It has been revised from the draft version dated October 2011 (BOEM 2011-050).

Because the theoretical foundation and background for the Net Benefits analysis is covered extensively in prior program documents (King, 2007), it is not repeated in this paper. However, the Bureau of Ocean Energy Management (BOEM) has updated data sources and improved the two simulation models used to estimate the program's Net Benefits.[1] Detailed documentation reports describing the factors used and the model design of the OECM and the Market Simulation (MarketSim) model will be published with the Proposed Final Program decision document (Industrial Economics, Inc. et al., 2012a and Industrial Economics, Inc., 2012b respectively). This analysis combines the measures provided by these models and geological, environmental, and economic data and evaluations by BOEM analysts into a Net Benefits value.

The Net Benefits analysis does not incorporate the costs of low probability/high consequence events, but this paper does consider catastrophic oil spills separately. The rarity and unpredictable nature of the many factors that determine the severity of a large oil spill's impact make efforts to quantify expected costs far less meaningful than the other measures developed by the OECM and MarketSim analysis. There is no question that a large extended discharge of oil resulting from OCS production activities could cause a catastrophic event which would greatly alter our estimate of the net benefits of leasing. But the extreme rarity of the occurrence of such an event (only one data point over the last 30 years, or six programs, and none with the enhanced safeguards in place today) leads to a miniscule statistical likelihood. Reducing such an effect to an expected value, as BOEM does for the other more routine factors evaluated in the Net Benefits analysis, would obscure the consequence of a discrete event like a catastrophic spill, should it actually occur. Furthermore, the potential costs of a catastrophic oil spill, should it occur, are extremely variable and must be extrapolated from a very limited data set, rendering them more speculative than are the other Net Benefits estimates. Hence, BOEM assesses the possible risks and impacts of a catastrophic spill outside the Net Benefits analysis. BOEM deals with risks and conditional estimates for such an event in a separate assessment in the last part of this document.

Net Benefits Analysis

The Net Benefits analysis is a benefit-cost assessment by program area of the national gain from anticipated production of economically recoverable oil and natural gas

1The Offshore Environmental Cost Model (OECM) calculates the environmental and social costs of the recommended and alternative options for each program area. The Market Simulation Model (MarketSim) estimates the energy market's response to the program's Exploration and Development (E&D) scenarios, calculates conservation and energy substitutions for OCS oil and gas under the No Sale Option (NSO) in each program area, and calculates the net change in consumer surplus anticipated from the program.

resources expected to be leased and discovered as a result of the program. The results summarized in the decision document provide the Secretary of the Interior estimates of benefits and costs from holding a sale (or sales) or selecting the No Sale Option (NSO) in any or all of six program areas.[2] The measure of Net Benefits reflects the net producer, consumer, and fiscal gains to the nation above the finding and extraction costs, as well as the environmental and social costs, from the anticipated exploration, development, and production in each program area. The analysis also adds to the program area estimates of the environmental and social costs avoided, and deducts the domestic profit forgone, which are associated with obtaining replacement energy from other sources that the markets would tap should any of the NSOs be selected.

Selection of the NSO in any of the program areas means that no new leasing would take place in that area for at least five years. Thus, domestic oil and natural gas supply would be reduced by the amount of production expected from the no sale area.[3] Without this new production, there would be less domestic oil and natural gas supply but little change in domestic demand for energy. The resulting gap between domestic demand and supply would be met by additional imports (primarily of foreign sourced oil delivered by supertankers), more domestic onshore oil and gas production, more biofuel and coal production, and other energy market substitutes. Energy usage would be a bit lower than it would be with the sale(s) due to a slight increase in domestic prices (primarily for natural gas). The section titled *Market Simulation Model* details how MarketSim estimates the energy sources that would replace outer continental shelf (OCS) production anticipated from this program should the NSO be chosen in one or more program areas.

The Net Benefits analysis provides the Secretary of the Interior with a logically consistent basis for considering the values and alternative sale options for each program area. It only includes the effects of the upstream oil and gas activities, not those associated with the downstream production (e.g., refining) of petroleum products.[4] Other factors such as possible future innovations in energy efficiency or renewable energy technologies are not included in the Net Benefits analysis. Since the Secretary's authority is confined to a decision on the leasing program options, the Net Benefits analysis focuses on those options and not other policy levers that might change the baseline energy forecast. The baseline is a policy-neutral energy forecast provided by the U.S. Energy Information Administration (EIA). Although other changes such as new energy efficiency standards and renewable energy technologies are not considered, they are discussed in a related program document titled *Energy Alternatives and the Environment* (Industrial Economics, Inc., 2012c).

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2 If the NSO is selected for each program area, it is identical to the no action alternative (NAA) referred to in the EIS. The effects of the NAA are the market response and corresponding environmental and social costs absent a Five Year Program.

3 Conceivably the oil and gas supply may only be delayed until a future program could offer the NSO area, but this analysis does not incorporate that possibility. Previous administrative decisions to remove areas from Five-Year schedules have proved durable, and this makes future offers of the area highly uncertain, and in any event the substantial present value discount that would be applied to any such production makes its omission from future supplies insignificant for this analysis.

4 The *Market Simulation Model* section discusses the energy market substitutions of the NSO which would result in approximately the same downstream effects.

Methodology

The Net Benefits analysis enumerates three levels of domestic benefits and costs associated with the program: *net economic value, net social value,* and *net benefits*. Figure 1 summarizes the calculations completed for each program area to quantify the private and social gains and losses associated with adopting the proposed decision option for that area, as opposed to choosing the NSO. Values calculated for the program are discounted at a (real) social discount rate of three percent to the beginning year of the program (2012).

The first row of Figure 1 calculates the gross revenue of anticipated oil and gas production over the lifetime of the leases issued in a sale area under the Proposed Final Program. It measures the direct contribution of that area to the gross domestic product at the different assumed oil and gas price levels. The basic approach of the Net Benefits analysis is to adjust this gross value to reflect the full scope of gains to the nation by estimating the value gained from this economic activity as well as losses associated with generating that economic value. The rest of Figure 1 lists the categories of benefits and costs involved in this Net Benefits calculation for each Proposed Final Program sale area.

Figure 1: Components of the Net Benefits Analysis

1	Anticipated Production of the Program Area	x	Assumed Oil and Gas Price Levels	=	**Gross Revenue**
2	Gross Revenue	-	Private Finding and Production Costs	=	**Net Economic Value (NEV)**
3	NEV	-	Environmental and Social Costs *less* Environmental and Social Costs of Energy Substitutes (Resulting from the NSO)	=	**Net Social Value (NSV)**
4	NSV	+	Consumer Surplus Benefits *less* Lost Domestic Producer Surplus Benefits	=	**Net Benefits**

The second row measures the net economic value (NEV), sometimes called economic rent, generated by the new OCS production.[5] The NEV can be viewed as the profit available to be shared by the oil industry and the government from producing the OCS resources made available. Because this is a surplus remaining after the costs of exploration and production have been subtracted from gross revenue, it can be shared between producers and government without distorting the allocation of capital and labor to this activity. To the extent that factors of production employed as a result of sales in the program area have less lucrative opportunities elsewhere, the selection of the NSO would impose additional private costs in the form of lost wages, etc. This analysis

5 Economic rent is typically defined as payment for goods and services beyond the amount needed to bring the required inputs into a production process and sustain supply.

ignores these potential private losses because no reliable measures exist to calculate them. However, as explained in the next two paragraphs it does include two offsetting costs associated with the NSO.

The third row measures the net social value (NSV) of sales in the program area by incorporating the external costs of the OCS activity relative to those from the NSO.[6] Such external costs occur because producers and consumers do not bear all the costs generated by the program. The process used here estimates both the external costs associated with OCS production enabled by offering the area and those that would arise from replacements for that production which would occur absent any part of the program under the NSO. In this formulation, consumption of oil and natural gas and thus the external effects like CO_2 emissions associated with fossil fuel use remain essentially the same so they are omitted in this analysis. Because external effects attend both OCS and replacement production situations, the NSV calculation combines the *difference* between those costs with the NEV to calculate the NSV for the Proposed Final Program areas.

The fourth row adds the net consumer surplus gain from the each program area to this NSV. Consumer surplus refers to the benefit buyers enjoy because they do not have to pay as much as they would have been willing to for the good consumed. A producer surplus also occurs when producers receive more than the minimum price they would have been willing to accept to produce and sell the good. Incremental oil and gas supplied from each program area increases domestic consumer surplus by reducing oil and natural gas prices and increasing overall consumption slightly. However, it also decreases both domestic and foreign producer surplus by reducing the price producers receive and by displacing some sales they would make under the NSO. This lost producer surplus from the program lowering oil and natural gas prices and displacing replacements under the NSO can also be viewed as a measure of the NEV lost due to the program. Rather than deduct this lost NEV in the second row of Figure 1, the domestic portion of it is accounted for in the fourth row calculation. The net consumer surplus benefits added to the NSV in this analysis thus reflects the difference between the increase in domestic consumer surplus and the decrease in domestic producer surplus attendant to the program. Basically, this net consumer surplus gain measures the domestic consumer surplus benefit from the resulting lower price of imported oil and gas relative to the existing price level for those imports.

Net Economic Value Derived from a Program Area

The first step in the Net Benefits analysis is calculation of the net economic value (NEV) associated with lease sale(s) in each program area. Overall, NEV measures an element of social value that may be generated by lease exploration, development, and production activities under certain assumptions about oil and gas prices, resources, etc. The approach to determining NEV is similar to customary cash flow modeling, except that the calculations are done at a highly aggregated level and discounted at the social rate. As explained below, the calculations start with the total production that BOEM estimates to be profitable to explore for and produce in the area at these assumed oil and gas prices.

6 External costs occur when oil and gas production results in effects like air pollution that cause uncompensated environmental costs or loss of property value that cause uncompensated social costs.

Then aggregate costs of equipment, plant, labor, etc. are subtracted from aggregate revenues (production times price). Note that this analysis does not attempt to model individual firms or projects.

BOEM calculates the NEV for each program area using anticipated production amounts and rates consistent with the projected undiscovered and un-leased portions of the economically recoverable resources in each program area. The section titled *Assumptions and Input Data* describes how BOEM experts estimate these amounts and rates. For the sake of consistency, the NEV estimates are based on the same schedules of exploration, development, and production activities (E&D scenario) modeled in the OECM to obtain the environmental and social costs for each program area and, again, in the environmental impact statement (EIS) to evaluate the impact of that activity on the human environment.

Two broad clarifications about NEV can be stated here. First, the NEV is based on discounting, at a social rate of three percent, the revenue from the new OCS oil and gas produced minus the costs of exploration, development, and production. In contrast, the underlying resource assessment is properly conducted using private discount rates appropriate for the risk and return expected in the oil sector. This is the case because the NEV analysis starts by identifying the amount BOEM expects companies will regard as profitable. For that amount the analysis subsequently weighs the cost of labor, equipment, etc. needed to produce those resources against the value of the produced oil and natural gas. To the extent these production costs reflect opportunity costs of dedicating the labor, equipment, etc., to the OCS activities instead of to alternative uses for those inputs, this provides a measure of social value.

Second, note that NEV analysis alone does not ensure that the resulting program area measures represent their maximum values conditional on optimal configuration of sale offerings. Decisions related to sale configurations within a program area are postponed until the date of each sale approaches. However, it is important to know now whether there appears to be at least some acreage within each of the areas being considered for inclusion in the Five Year Program that appears to be worth leasing in the near term. Accordingly, BOEM conducted a “hurdle price” analysis on lease sale timing, discussed in Section III.B. “Fair Market Value Options” in the decision document, to establish whether inclusion of each of the six program areas being considered in this Proposed Final Program is consistent with economic optimality. The purpose of this optimal timing analysis is to examine the possibility that withholding an area until the next program might be of greater value to society, considering the general characteristics of geologic fields that may reside in an area. That analysis has demonstrated that at projected resource prices, all program areas under consideration are likely to have one or more geologic fields that are optimal to offer for lease under the Five Year Program. Thus, BOEM concludes that there is no sound economic basis for excluding any of the program areas under consideration from inclusion in the Five Year Program.

The equation for calculating NEV for a program area is:

$$NEV_i = \sum_{t=1}^{n} \left[\frac{(AG_{it} * PG_t) + (AO_{it} * PO_t) - C_{it}}{(1+r)^t} \right]$$

where:

NEV_i = the estimated net present value of gross economic rent in the i^{th} program area. i.e., "net economic value".
AG_{it} = the anticipated production of natural gas from program area i in year t
PG_t = the natural gas price expected in year t
AO_{it} = the anticipated production of oil from program area i in year t
PO_t = the oil price expected in year t
C_{it} = a vector of exploration, development, and operating costs
r = a social discount rate
n = years from start of the program until the end of last production from leases sold within the Five Year Program timeframe

BOEM determines the NEV for three separate flat real price cases assumed in the development of the E&D scenarios and corresponding production deemed likely from each of the proposed program areas. Table 1 summarizes these NEV estimates.

Table 1: Net Domestic Economic Value

	Net Economic Value ($ billions)*		
	Low Price	**Mid-Price**	**High Price**
Central GOM	36.66	153.59	287.16
Western GOM	10.31	38.73	69.56
Eastern GOM (2 sales)	**	2.30	5.32
Chukchi Sea	5.02	31.06	135.37
Beaufort Sea	0.14	3.68	16.57
Cook Inlet	1.56	3.71	12.30

All values are discounted at a real discount rate of 3 percent.
*The low-price case represents a scenario under which inflation-adjusted prices are $60 per barrel for oil and $4.27 per mcf for natural gas throughout the life of the program. Prices for the mid-price case are $110 per barrel and $7.83 per mcf. Prices for the high-price case are $160 per barrel and $11.39 per mcf.
** Given current information, no production is expected from the Eastern GOM Program Area at the low-price case, whether from one or two sales; therefore NEV is assumed to be zero. If exploration occurs, NEV could be either negative—if no production results—or positive—if successful exploration leads to production. The estimated value of Eastern GOM resources is highly sensitive to changes in information, so placing a second sale on the schedule would provide flexibility to adapt to such changes.

The NEV, generated as a result of the market value of production exceeding the cost of exploration, development, and production, is captured in part by the federal government and accrues to the general public in the form of leasing revenues (i.e., cash bonuses, rentals, and royalties) and corporate income tax revenues paid by lessees, and retained by lessees as economic rents roughly in the form of corporate profits. Conceptually, only the U.S. share of the NEV contributes to domestic welfare, so the Net Benefits calculation reported here includes only the likely domestic share as is determined below.

The Federal share of the NEV estimates shown above in Table 1 ranges from 45% to 65% for the different program areas and price cases. A recent study done for BOEM and the Bureau of Land Management estimates that the taxpayer share (called government take) under the current U.S. offshore fiscal system from representative future OCS projects will be somewhat larger (between 64% and 79%) (Agalliu, 2011).[7] Lower price and perhaps higher production cost assumptions relative to those used here account for the larger government share found in this external study. In any case, the bulk of NEV is collected by the domestic fiscal system on behalf of U.S. taxpayers so all of it contributes to domestic net benefits.[8]

The private sector share of NEV that flows to U.S. citizens also contributes to domestic net benefits. While a portion of the private share of the NEV derived from new OCS production flows to non-U.S. citizens through profits going to foreigners holding shares in U.S. oil companies, counter flows go to U.S. citizens holding shares in the foreign oil companies active on the U.S. OCS.[9] BOEM does not have information on the nationality of shareholders in OCS operators, but aggregate data available show U.S. holdings of all types of foreign securities is slightly higher ($6.2 trillion) than foreign holdings of U.S. securities ($5.9 trillion).[10] BOEM has no reason not to expect the same pattern to hold for those companies that win new leases under the program, so BOEM assumes foreign shareholders in U.S. oil companies and U.S. shareholders in foreign oil companies active on the OCS balance each other. That leaves only the need to net out the private share of NEV going to foreign shareholders in these foreign oil companies. As a rough proxy for the share of foreign beneficial owners of activities on the U.S. OCS, BOEM uses EIA's estimate that 13% of U.S. domestic oil supply and 10.6% of U.S. domestic gas supply are produced by subsidiaries of foreign oil companies.[11] Applying these foreign interest shares of each product to the average 35% to 55% private sector share of NEV, BOEM finds that about 95% of total NEV generated by the program

7 See *Comparative Assessment of the Federal Oil and Gas Fiscal System,* page 5. Available at http://www.boem.gov/Oil-and-Gas-Energy-Program/Energy-Economics/Fair-Market-Value/Fair-Return-Report.aspx

8 The government tax and leasing revenue portion of the NEV calculation does not separate out special incentives or subsidies. Such government subsidies do not change the NEV, only how that NEV is distributed between the government and producing firms. Special tax considerations such as the depreciation of tangible and intangible expenses similarly do not affect total NEV, only the timing and magnitude of payments between producers and the government. Subsidy effects also occur in replacement sources that would be used under the NSO, so their omission in this relative analysis merely assumes that these subsidies are proportionally equal in the two supply sources. Subsidies and taxes that affect downstream consumption, such as the gasoline tax, are not considered in the Net Benefits analysis because they are beyond the scope of the analysis and are not within the authority of the Secretary to control.

9 All companies that operate on the OCS are American corporations, but they may be subsidiaries of foreign parent companies.

10 See http://www.bea.gov/newsreleases/international/intinv/intinvnewsrelease.htm

11 See http://www.eia.gov/emeu/finance/fdi/oilgas.html

accrues to U.S. interests. Accordingly, BOEM includes that adjustment in the NEV reported above for each program area. On the other hand, foreign shareholders invest a considerable amount of money in the U.S. economy to buy their shares (to obtain the profits). It would be difficult to estimate those investments, and BOEM has not reduced national costs to account for this inflow of capital.

BOEM notes that the NEV is different from the assessment of the regional economic impact of OCS activities measured elsewhere. (See the *Equitable Sharing Analysis* for the economic impact of the program in part IV.C.4 of the Proposed Final Program decision document.) A regional economic impact analysis measures the gross value produced by, or relative importance of, different industries or sectors, such as oil and gas production, recreation, etc., within a local or regional economy. But that approach does not reveal the contribution to social wellbeing from those activities because it does not consider the alternative activities forgone to provide these gross values. Accordingly, the NEV concept of value is a more appropriate measure to compare the costs and benefits of policy alternatives.

Net Social Value Associated with a Program Area

Whereas the NEV analysis considers the private costs incurred by the firms that explore for and develop OCS oil and gas resources, society also incurs external or environmental and social costs from OCS activities and facilities associated with offshore oil and gas production. These types of costs would also arise from substitute sources of energy that would be tapped in the absence of this new OCS production. The net social value (NSV) is the NEV less the present value of the difference between the environmental and social costs anticipated from the program area options and those costs for sources that would replace OCS production if any of the NSOs were selected.

The external costs arise from environmental (e.g., pollution effects on human health or agricultural productivity) and social (e.g., oil spill effects on recreational fishing or beach use) damages which can occur during the exploration, development, production, and transportation of OCS oil and gas resources or from their NSO replacements. The external costs reflect actions taken by lessees under applicable regulations to prevent oil spills, mitigate air pollution, and avoid accidents. The private costs incurred to mitigate these external effects are included as avoidance and abatement costs in the NEV analysis.

The BOEM uses the OECM to calculate the external environmental and social costs from the recommended option in comparison to the NSO replacement energy sources as identified by MarketSim for each of the program areas. Before turning to the net environmental and social cost calculation in Table 4, it is important to appreciate the scope of effects quantified by these two models.

Market Simulation Model

The Market Simulation Model (MarketSim) estimates the substitutions for offshore oil and gas production that would occur in the absence of sales in each of the program areas. MarketSim calculates the additional imports, onshore production, fuel switching, and reduced consumption of energy that would replace the production in each program area should any of the NSOs be selected, as well as the associated change in net domestic consumer surplus.

MarketSim is an Excel-based model for the oil, gas, coal, and electricity markets calibrated to a special run of the EIA's National Energy Modeling System (NEMS). The NEMS baseline used in the MarketSim is a modified version of the EIA's 2009 Annual Energy Outlook Reference case (updated to reflect the American Recovery and Reinvestment Act) which includes no new OCS lease sales, i.e., selecting the NSO for every program area. [12] Removing the EIA's expectation of production from new OCS leasing allows us to investigate alternative new OCS leasing scenarios within the EIA's broad energy market projection using MarketSim. The Net Benefits analysis makes no assumptions about future technology or policy changes other than those reflected in the EIA NEMS forecast.[13]

BOEM introduces the E&D scenario from each program area into the MarketSim as a shock to the baseline, i.e., the NSO in each program area, triggering a series of simulated price changes until each fuel market reaches equilibrium where supply equals demand. MarketSim uses price elasticities derived from NEMS runs and from other published elasticity studies (examples: Dahl, 2010 and Serletis, 2010) to quantify the changes that would occur to prices and energy production and consumption over the 40-year period of production from the program area. Tables of the demand and supply elasticities used in the model are shown in the MarketSim documentation, *Consumer Surplus and Energy Substitutes for OCS Oil and Gas Production: The Revised Market Simulation Model* (Industrial Economics, Inc., 2012b).

There are important enhancements to the MarketSim modeling approach for this analysis compared to past Five Year Programs. The current version increases both the scope and detail of modeled fuel markets by adding coal and electricity markets to account for substitution between alternate fuel sources. It also incorporates feedback effects between the markets for substitute fuels using cross-price elasticities between the fuels. For instance, a gas price decrease from added supplies increases the quantity of gas demanded which then decreases the demand for coal, which in turn decreases the price of coal thereby dampening the initial increased gas demand. In order to more accurately depict this substitution, the current version also increases the level of detail at which it models production and consumption. Each fuel's demand is decomposed into residential, commercial, industrial, and transportation uses with its own-price and cross-price elasticity specific to each submarket. Additionally, each fuel is modeled for up to eight components of supply (e.g., oil from domestic onshore, domestic offshore, Alaska, Biofuels, Other and imports). This complexity allows MarketSim to simulate changes in energy prices and the resulting substitution effects between fuels in the presence of changes in OCS oil and gas production. Additional details about how MarketSim models

12 NEMS projections including production from new OCS leasing is typically reported in EIA's Annual Energy Outlook.

13 See *Energy Alternatives and the Environment* for a discussion of other technology and policy changes (Industrial Economics, Inc. 2012c).

fuel substitutions across energy markets and sources are described in the MarketSim documentation (Industrial Economics, Inc., 2012b).

For the NSV calculation, BOEM compares baseline MarketSim results with results when production from the program area is included to determine the quantity and type of fuel use that would occur if no new leasing were permitted in the OCS program area.[14] The energy market substitutions must be factored into the Net Benefits analysis because the selection of the NSO in one or more program areas will lead to slightly higher oil and gas prices and additional domestic production, increased imports, and fuel switching to meet the continuing demand for oil and gas resources.[15]

Table 2 shows, for the mid-price scenario, the energy market substitutions expressed in barrel of oil equivalent percentages that would occur from excluding all planning areas.[16] To illustrate the calculation method, consider the measure which shows the replacement of 60% of forgone OCS production by oil imports. With all program areas included, the total offshore oil production is estimated to be 50.3 BBOE under the mid-price scenario over 40 years. If the NSO were selected in each program area, the offshore production baseline is projected to be only 40.3 BBOE. The difference of 10 BBOE in forgone new OCS production would be replaced with increased imports, onshore production, etc. To determine the percentage of the forgone OCS production replaced by increased oil imports, BOEM subtracts imports anticipated under the Proposed Final Program (149.3 Bbbl) from the imports expected in the baseline (155.3 Bbbl) and divide by the difference in total forgone OCS production [(155.3-149.3)Bbbl/10 BBOE], which equals 0.6 or 60% in percentage terms.

14 MarketSim is a national model and does not look at variation in gas prices in different regions.
15 The MarketSim does not include estimates of changes in production from existing OCS leases in response to the selection of the NSO for one or more program areas. While this may be considered for future versions of the model, any such OCS response effect would depend on numerous factors, such as whether the decision was for one or multiple areas, the specific areas to which it applied, companies' beliefs as to whether the decision implied the direction for future programs, and changes in the relative attractiveness of opportunities elsewhere for investment as decisions were made. Industry could pursue strategies that create short-term and long-term effects with offsetting results. Therefore, it is not even certain that the OCS response effect would result in higher production over the period of analysis.
16 The actual percentages will vary between program areas depending upon whether a particular area is gas or oil prone.

Table 2: Substitute Energy Results of the No Sale Options[17]

Energy Sector	Percent of OCS Production Replaced
Onshore Production	**16%**
Onshore Oil	1%
Onshore Gas	15%
Imports	**68%**
Oil Imports	60%
Gas Imports	9%
Coal	**5%**
Electricity from sources other than Coal, Oil, and Natural Gas	**3%**
Other Energy Sources	**2%**
Reduced Demand	**6%**

On an aggregate basis, these estimates indicate that 94 percent of the likely new OCS production would be replaced by increased production from other fuel sources, generating the attendant environmental and social costs for that substitute activity. OECM estimates those costs that occur within the U.S. boundaries including territorial waters. The remaining forgone OCS production is not replaced, but rather, the slightly higher market clearing prices for oil and gas reduce quantity demanded by six percent of the forgone OCS production.

Offshore Environmental Cost Model

BOEM employs the Offshore Environmental Cost Model (OECM) to determine both the environmental and social costs that would result from OCS activities in each program area and the costs that would result without new leasing (i.e., the No Sale Option). The BOEM updated the OECM inputs and model structure from previous Five Year Programs for analyzing this program.

The new OECM is an Access-based model that uses the levels of OCS activity from the E&D scenarios employed in the NEV and the EIS along with the energy market substitutions from MarketSim to calculate net environmental and social costs. The OECM analysis evaluates the following six environmental and social cost categories for each program area and replacement NSO source. The impacts from each category are summed together, with equal weighting, to derive the environmental and social costs of the program relative to the NSO.

<u>Environmental cost categories</u>

Air Quality: The monetary value of the human health, agricultural productivity, and structural damage caused by emissions generated by oil and gas activity.

17 Percentages in this table can be interpreted as "5% of the reduced production from the selection of the NSO in a program area will be replaced with coal."

- Emissions are calculated based on activity levels and the environmental and health effects are determined by the dispersion and monetization done by the Air Pollution Emission Experiments and Policy (APEEP) analysis model.[18]
- A summary of the methodology is found in the section titled *OECM Air Emissions Modeling*.

Ecological: Restoration cost for habitats and biota injured by oil spills.

- Consistent with the standard economic view of natural resources as assets that provide flows of services, ecosystems are understood to provide a flow of ecosystem services. These services are valued by society, as demonstrated by the willingness to pay for their protection.
- Changes in the quality or quantity of these services (e.g., due to ecosystem injuries caused by oil spills) have implications in terms of the value of the benefits they provide.
- The model uses a habitat equivalency analysis (HEA) approach in which the cost of creating the equivalent habitat area measures the dollar damages assigned to the lost ecosystem services.
- A summary of the considerations included in this estimate is found in the section titled *OECM Ecological Modeling.*

<u>Social cost categories</u>

Recreation: The loss of consumer surplus that results when oil spills interfere with recreational offshore fishing and beach visitation.

- Estimates are based on the use value of recreational fishing and beach visitation because they capture the primary recreational services of coastal and marine resources that would be affected by OCS activity.
- These are the services for which relevant data are generally available on a consistent, national basis.

Property Values: Impacts of the visual disturbances caused by offshore oil and gas platforms and losses in the market value of residential properties caused by non-catastrophic oil spills.

- Impact is defined as the annual loss in potential rent from residential properties that result from visual disturbances from platforms as well as from damage from oil spill events.
- The property damage from oil spills is calculated as the product of the property value per linear meter of beach, the after tax discount rate, the fraction of year taken up by the event, and the length of oiled shore.

Subsistence Harvests: The replacement cost for marine subsistence species members killed by non-catastrophic oil spills in Alaska.

18 Available at https://seguecommunity.middlebury.edu/view/html/site/nmuller/node/2367900

- The model assesses the impact of OCS oil and gas activities on Alaska harvests by estimating oil spill-related mortality effects among general subsistence species.
- The model assumes that all organisms killed by oil spills would have been harvested for commercial or subsistence purposes, determines the subsistence component of this lost harvest, and calculates a replacement cost.

Commercial Fisheries: The loss from extra fishing effort imposed by area pre-emption due to the placement of oil and gas infrastructure (platforms and pipelines).

- The model assumes that there will be buffer zones around platforms. In most cases the buffer zones will be a circle with a radius of 805 meters (0.5 miles).
- The model also assumes that the total amount harvested is unaffected by oil and gas infrastructure since nearly all fisheries in OCS waters are managed with annual catch limits set below the harvestable biomass. But the buffer zones force the harvest activities to less efficient fishing areas.
- Non-catastrophic oil spill impacts are likely to result in only temporary fishery closures. Since most fisheries are managed through catch limits, a temporary closure will still give the industry ample opportunity reach the catch limit.

The OECM uses the parameters set forth in the E&D scenario to estimate annual oil production and location of occasional non-catastrophic spills associated with each platform group. The OECM feeds this information into the Oil Spill Impact Modeling Program (SIMAP) which uses regressions to estimate the physical damage from oiling.[19] Then, using impact equations developed for the cost categories of recreation, property values, subsistence use, and ecological effects, the OECM employs the SIMAP regression outputs and anticipated spill size and location data to estimate costs. Due to the unique characteristics of the air quality and commercial fishing cost categories, the OECM employs the output from external modules to estimate non-catastrophic oil spill effects associated with OCS production in these two categories. Table 3 shows the OECM estimates for the six environmental and social cost categories that make up the external costs for the mid-price case of the Central GOM program area.

19 SIMAP is an oil spill impact modeling system providing detailed predictions of the three-dimensional trajectory, fate, impacts and biological effects of spilled oil.

Table 3: OECM Cost Categories for Central GOM

	Program Costs	No Sale Option Costs
	$ millions*	
Environmental Costs		
Air quality	5,681	17,193
Ecological impacts	3.76	10.83
Social Costs		
Recreation	259	229
Property values	0.11	0.24
Subsistence use	0.00	0.01
Commercial fishing	0.17	0.00

All values are discounted at a real discount rate of 3 percent.
* These values are the OECM results for the mid-price case with prices of $110 per barrel and $7.83 per mcf.

The OECM is not designed to represent impacts from global climate change, catastrophic events, or impacts to unique resources such as endangered species. In the case of global climate change, BOEM would anticipate little differential effect compared to the NSO. For catastrophic events and impacts on unique resources, it is worth mentioning that such events and impacts are plausible in the NSO as well and their rarity make it problematic to develop statistical representations for them comparable to those for the other environmental effects modeled in OECM. In any case, the Final Five Year EIS (BOEM 2012a) discusses program relevant aspects of global climate change, catastrophic events, and impacts on unique resources. The impacts of catastrophic spills are discussed in the section entitled Catastrophic Oil Spill Analysis. The separate report, *Inventory of Environmental and Social Resource Categories Along the U.S. Coast* discusses information on resources at risk and potential impacts from a catastrophic oil spill (Industrial Economics, Inc., 2012d).

Because the largest social and environmental costs modeled for the 2012-2017 proposed program decision document are from OCS oil spills and air emissions and because assessing ecological values is not a widely understood topic, BOEM includes additional discussion below of how the OECM model handles these categories.

OECM Oil Spill Modeling

The general public views oil spills as the most serious threat posed by the OCS program. The environmental effects of oil spills and the costs associated with those effects vary widely depending on variables such as the amount and type of oil spilled, the location of the spill, whether the spill hits shore, the sensitivity of the ecosystem affected, weather, season, and so forth. While it is not possible to deal with all these variables, information on the environmental and social costs associated with past oil spills have been relatively well documented so there is a reasonable basis for oil-spill risk and cost modeling in the literature.[20]

20 Oil spill information for the Arctic is based on SIMAP and earlier type A models which can be designed for both cold and warm water (French et al. 1996).

The risk of an oil spill includes both the probability of spill incidents of various types occurring and the consequences of those incidents.

Spill risk = probability of spill x impacts of spill

The probability of a spill is a combination of both the likelihood a spill will occur and the sizes of spills that do occur. The likelihood of a spill is measured as the historic ratio of the amount spilled to the amount produced. The analysis performed for the proposed program uses aggregate estimates for all the spills that the model suggests are likely from the E&D scenario and anticipated production. The model also includes the oil spill risk from tankers transporting oil from offshore to onshore and from Alaska to the West Coast in measuring the impacts of the program. For tankers carrying oil imported to the U.S under the NSO, the analysis applies the same spill risks as used for tankers transporting crude oil from Alaska to the West coast of the contiguous 48 states. The spill rates and sizes used in the model are based upon OCS spills from 1996-2010 of less than 100,000 barrels (Anderson, McMahon, and LaBelle, 2012). Data from that period captures the non-catastrophic spill rates experienced during the modern deepwater era of offshore drilling. New technologies and safety procedures make the oil spill rates from 1996-2010 more representative of future activity than those calculated over a longer historical period.

Impacts of a spill depend on the spill size, oil type, environmental conditions, present and exposed resources, toxicity and other damage mechanisms, and population/ecosystem recovery following direct exposure. OECM uses the existing and well-documented SIMAP (French-McCay, 2004 and French-McCay, 2009), to project consequences associated with a matrix of potential conditions. Region-specific inputs include habitat and depth mapping, winds, currents, other environmental conditions, chemical composition and properties of the oils likely to be spilled, specifications of the release (amount, location, etc.), toxicity parameters, and biological abundance.

Spills could occur in the context of OCS oil and gas exploration and development or in the context of imports that might serve as substitutes to OCS production. The SIMAP summarizes data that quantify areas, shore lengths, and volumes where impacts would occur with regression equations to simulate spills of varying oil types and sizes in each of the planning areas under a wide range of conditions. The results of these equations are then applied within the OECM. The oil spill modeling approach cannot and does not try to measure the effects of any individual spill.

The spill rates and sizes in the OECM also do not include huge, catastrophic spills such as the one from the *Deepwater Horizon*. The OECM is not designed to address catastrophic spills because the oil spill modeling that forms the basis of the OECM is conducted through SIMAP which models smaller surface releases. Subsurface releases likely in a catastrophic spill would have very different oil behavior and fate than what is currently modeled. As a result, if a catastrophic spill volume was included in the model, the model would treat the large volume spilled as a series of smaller spills thereby producing an unrealistic estimate. Doing so would mask the cost of the smaller, more probable events. To allow both types of spills to be accurately calculated, the potential effects of catastrophic spills related to the Proposed Final Program are discussed in the section titled Catastrophic Oil Spill Analysis.

OECM Air Emissions Modeling

The OECM estimates the level of air emissions associated with drilling, production, and transportation for any given year based on the 2012-2017 proposed program E&D scenarios and schedule.[21] Oil and gas exploration and development will lead to emissions of sulfur dioxide (SO_2), oxides of nitrogen (NOx), volatile organic compounds (VOCs), particulate matter (PM), and other air pollutants that may adversely affect human populations and the environment. To account for these effects, the OECM includes an air quality module that calculates (1) the emissions—by pollutant, year, and planning area—associated with a given E&D scenario and production rate and, (2) the monetary value of the environmental and social damage caused by these emissions, estimated on a dollar-per-ton basis. The model estimates emissions based on a series of emissions factors derived from BOEM data, models the dispersion of these air emissions for planning areas along the coast of the contiguous United States, and converts the modeled emissions to monetized damages using a modified version of the APEEP developed by Muller and Mendelsohn (2006).[22]

Emissions factors for GOM activity were derived from the BOEM Gulfwide Offshore Activities Data System (GOADS) software. For Alaska, the emissions are estimated based on the manufacture and the Environmental Protection Agency emissions estimates for the equipment expected to be used. Emissions are scaled based on continual activity for the maximum amount of time the equipment might be in use. For tankers carrying oil imported to the U.S. under the NSO, the analysis applies the same emission factors used for tankers transporting crude oil from Alaska to the West coast of the contiguous 48 states. Emission factors for onshore oil and gas production for the contiguous United States under the NSO scenario are based on the Western Regional Air Partnership‘s (WRAP) 2002 emissions inventory for oil and gas activities in twelve western states. These states include Alaska, Arizona, California, Colorado, Montana, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, and Wyoming (WRAP, 2009). Because the WRAP inventory does not separate onshore and offshore emissions and the database is being used specifically for calculating onshore emissions, Alaska and California were excluded. Emission factors were developed for onshore oil and gas production by dividing the emissions estimates from the WRAP inventory (with some adjustments) by Department of Energy estimates of onshore oil and gas production in the ten states analyzed.

21 The Net Benefits analysis does not include the environmental and social costs of the downstream impacts of consuming oil and natural gas. This analysis considers only actions within the Secretary’s authority. Furthermore, most of the downstream emissions will stay approximately the same regardless of whether or not there is a new program.

22 The model monetizes damages associated with emissions in Alaska Planning Areas by scaling estimates of the monetized damages from APEEP estimates of damages per ton of emissions for the Oregon-Washington Planning Area. The emissions were scaled for both distance from shore and population.

The specific air pollution impacts that the OECM examines and monetizes include:

- Adverse human health effects associated with increases in ambient $PM_{2.5}$ and ozone concentrations;
- Changes in agricultural productivity caused by changes in ambient ozone concentrations; and
- Damage to physical structures associated with increases in SO_2.

Because human health effects generally dominate the findings of more detailed air pollution impact analyses (EPA, 2010), excluding emissions-related changes in visibility, forest productivity, and recreational activity from the analysis is unlikely to have a significant effect on the results.

OECM Ecological Modeling

The OECM treatment of ecosystem service losses covers some but not all such effects.[23] An appropriate evaluation of ecological and ecosystem service values involves analyzing the change in ecological and ecosystem service values of the program relative to the NSO. As in the other categories, OECM applies this conceptual approach in its evaluation of ecological and ecosystem service values for the program relative to the NSO by accounting for changes in ecological and ecosystem service values for several categories including ecological losses from oil spills, air quality, commercial fishing, recreational offshore fishing, beach use, property values and aesthetics, and subsistence harvest.

OECM does quantify certain ecosystem service losses. For the program costs it uses the probability of oil spills from new oil platforms and pipeline installations to estimate the associated ecosystem service losses. For the NSO it uses the increased probability/frequency of oil spills due to increased oil imports transported by tankers to estimate the likely associated loss of ecosystem services. In both instances, ecological losses are calculated via habitat equivalency analysis (HEA) within the framework of a natural resource damage assessment where the cost of restoration that equates ecological losses from the oil spill to ecological gains from restoration is used as the monetary measure of ecological damages.

OECM does not quantify other identifiable ecological and ecosystem service losses. For example, the Net Benefits analysis does not measure the effects of habitat disturbances from project footprints associated with new oil platforms, pipeline installations, drilling rigs, and any other new infrastructure (beyond incremental air emissions) on the OCS nor passive use losses for marine mammals and other threatened, endangered, and sensitive species adversely affected under the Proposed Final Program. But it also does not count ecosystem service losses (beyond incremental air emissions) that would occur under the

23 Following the definition given by the Millennium Ecosystem Assessment, ecosystem services can be classified into four categories: Provisioning services – goods produced from ecosystems such as food, timber, fuel, and water (i.e., commodities); Regulating services – benefits from regulation of ecosystem processes such as flood protection, disease control, and pollination; Cultural services – nonmaterial benefits from ecosystems such as recreational, aesthetic, and cultural benefits; and Supporting services – services necessary for production of other ecosystem services such as nutrient cycling and soil formation.

NSO. Such losses would arise from incremental habitat disturbances for development of additional onshore oil and gas, renewable energy, and coal resources. Passive uses associated with terrestrial mammals and other threatened, endangered, and sensitive species would also be adversely affected due to incremental development of onshore energy substitutes for offshore oil and gas not developed.

In general, the OECM estimates several types of use values associated with ecological and ecosystem services resulting either from direct or indirect use.[24] While OECM attempts to quantify the primary categories of ecological and ecosystem service values, it is not designed to represent impacts to unique resources such as endangered species. Such values would be associated with nonuse or passive use values.[25]

Evidence of nonuse values can be found in the trade-offs people make to protect or enhance environmental resources that they do not use. Nonuse or passive use values could be apparent under both the program and the NSO. Overall, an evaluation of nonuse or passive use values would involve determining the trade-offs made by the public between ecological and species impacts resulting from the incremental oil and gas development under the program versus the ecological and species impacts that would occur onshore from the incremental development of onshore oil, gas, and coal resources under the NSO.

An evaluation of the net change in ecological and ecosystem service values can be accomplished with a variety of economic methods. The most comprehensive approach to evaluating the economic value of ecological and ecosystem service impacts associated with the program versus the NSO would involve administering a nation-wide Stated Preference (SP) survey to determine the trade-offs made by the public. However, SP surveys have their strengths and weaknesses, and require a significant investment in time and resources to conduct from start to finish. Several other factors complicate the ability to implement an SP survey, such as uncertainties about locations of oil and gas development both offshore and onshore, types and extent of habitat disturbances, and types and extent of species impacts that are likely to occur.

Absent the ability to conduct a sound new study, the application of benefits-transfer technique can provide a reasonable approximation of various economic values. In general, the OECM utilizes benefits-transfer to estimate economic values associated with several categories of ecological and ecosystem services. The magnitude of those values

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24 Direct use involves human physical involvement with the resources, where direct use can be either consumptive use (e.g., activities that involve consumption or depletion of resources, such as logging or hunting) or non-consumptive (e.g., activities that do not involve resource depletion, such as bird watching). Indirect use involves the services that support the quality of ecosystem services or produced goods used directly by humans (e.g., climate regulation, flood control, animal and fish refugia, pollination, and waste assimilation from wetlands).

25 Nonuse values capture individuals' preferences for resources that are not derived directly or indirectly from their use. As such, nonuse values can accrue to members of the public who value resources regardless of whether they ever consume or use them. Factors that give rise to nonuse values could include the following: desire to preserve the functioning of specific ecosystems; desire to preserve the natural ecosystem to maintain the option for future use; feeling of environmental responsibility or altruism towards plants and animals

not captured by the OECM is difficult to determine without additional research. However, BOEM believes that the OECM provides a representative comparison of the relative size between the program and the NSO for most of the ecological and ecosystem service impacts likely to occur.

Net Environmental and Social Costs for a Program Area

Returning to the calculation outlined in row 3 of Figure 1, in order to obtain the most accurate representation of the differential costs between a program area and the NSO, BOEM must estimate the environmental and social costs for both cases, with the difference in these costs from the program option and the NSO reflecting the net environmental and social costs of each program area. If OCS oil and, to a lesser extent, natural gas are not produced, imports of foreign oil will increase substantially. Most of this oil would be imported by tanker, entailing risks of oil spills and attendant environmental and social costs. Subtracting the environmental and social costs associated with these increased imports from the same category of costs related to OCS production yields the net environmental and social costs that BOEM attributes to new OCS activities. MarketSim quantifies the supply and demand side substitutions for offshore oil and gas production in the absence of lease sales in each of the areas. Then OECM calculates the environmental and social costs from both the program and the NSO for each proposed area.

Net Social Value Results from the OECM and MarketSim

The net environmental and social costs in program area i, NE_i, equal

$$NE_i = \sum_{k=1}^{s}\sum_{t=1}^{n}\left[\frac{E_{ikt}}{(1+r)^t}\right] - \sum_{k=1}^{s}\sum_{t=1}^{n}\frac{A_{ikt}}{(1+r)^t}$$

where:

NE_i = the net environmental and social costs in program area *i*.
E_{ikt} = the cost to society of the k^{th} environmental externality occurring in program area *i* in year *t*.
A_{ikt} = the cost to society of the k^{th} environmental externality occurring in program area *i* in year *t* from substitute production and delivery with the No Sale Option.
r = social discount rate

For program area *i*, the net environmental and social costs NE_i are subtracted from NEV_i to obtain that program area's net social value, NSV_i associated with OCS production. The NSV does not include consumer surplus benefits resulting from changes in the market price of oil and gas due to the program, which are added in the next stage of the Net Benefits analysis.

Table 4 shows the net external costs BOEM estimates for each program area. The costs associated with the NSO in Table 4 attribute the costs to the program area in which the

NSO was selected. For example, NSO impacts listed for the Chukchi Sea would not actually occur in the Chukchi Sea, but rather along the contiguous U.S. coasts and onshore in places of oil, gas, or coal production. The environmental and social costs of the NSO are distributed to program areas in Table 4 based on the expected production from each program area. If benefits and costs are not allocated to the area of production, it would be impossible to link a decision to lease in a specific program area to the full costs and benefits likely to result from that decision. The environmental and social costs per barrel of the NSO are roughly the same in each of the program areas, but may vary based on whether the program area is more oil or gas prone. Areas with more expected production will have higher NSO environmental and social costs.

Table 4: Environmental and Social Costs

	Program			**No Sale Option****			**Net**		
	($ billions)*								
	Low Price	Mid-Price	High Price	Low Price	Mid Price	High Price	Low Price	Mid-Price	High Price
Central GOM	3.47	5.94	6.94	10.08	17.43	20.26	-6.61	-11.49	-13.32
Western GOM	1.27	1.89	2.13	2.73	4.42	4.76	-1.45	-2.53	-2.63
Eastern GOM (2 Sale)	***	0.06	0.07	***	0.11	0.17	***	-0.05	-0.10
Chukchi Sea	0.04	0.08	0.15	0.24	0.43	1.03	-0.20	-0.36	-0.89
Beaufort Sea	0.02	0.02	0.03	0.05	0.58	2.30	-0.03	-0.56	-2.27
Cook Inlet	0.01	0.01	0.02	0.03	0.07	0.10	-0.02	-0.07	-0.09

All values are discounted at a real discount rate of 3 percent.
* The low-price case represents a scenario under which inflation-adjusted prices are $60 per barrel for oil and $4.27 per mcf for natural gas throughout the life of the program. Prices for the mid-price case are $110 per barrel and $7.83 per mcf. Prices for the high-price case are $160 per barrel and $11.39 per mcf.
** Selection of the No Sale Option for any program area would result in greater reliance on other sources of energy ("energy substitutes") to meet the demand that would have been satisfied with OCS oil and gas production anticipated from the proposed sale(s) for that area. These energy substitutes would also impose significant costs on society. See discussion above.
*** Given current information, no production is expected from the Eastern GOM Program Area at the low-price case; therefore environmental and social costs, whether from one or two sales, are assumed to be zero, as are the costs of replacing foregone OCS production with substitute sources of energy. If exploration occurs without subsequent production, the costs attributed to the sale(s) would be positive.

As shown in Table 4 for all program areas, the environmental and social costs of relying on the substitute sources of energy exceed those from producing the program area resources.[26] The difference between the costs of the energy market substitutes without a

26 BOEM notes the effects estimated by the OECM may be construed as substantial in absolute terms but fairly small in relative terms. For example, the OECM estimates environmental costs for the air emissions associated with a given E&D scenario. Although this is a large figure in monetary terms, these costs are small relative to the environmental costs associated with air pollutant emissions for the entire United States.

program area and the costs of each program area proposal is almost entirely due to two effects of the NSO. When oil from the new program is not available, increased onshore production of oil, gas, and other energy sources such as coal generates new air emissions. Also, replacement imports of oil cause corresponding increases in air emissions and oil spill risks from increased tanker operations along the U.S. coastal areas receiving the oil. Moreover, these added oil imports, along with additional onshore gas production, generate air emissions closer to population centers than occur with OCS oil and gas production. These discharges create a greater exposure influence on human health than do air emissions often many miles offshore. These extra external effects from replacement supplies are greater than those saved by the modest reduction in overall fossil fuel consumption anticipated under the NSO.

This positive environmental effect of the program omits several conceivable added external benefits. First, environmental and social costs resulting from foreign oil and gas production for export to the United States and from transportation of oil and gas to U.S. waters or borders are excluded from the model. Air emissions including greenhouse gases associated with increased ocean shipments adds to global if not U.S. environmental effects from oil production. Second, more coal usage in place of gas in electricity generation under the NSO would create further adverse environmental consequences. However, these downstream effects are omitted from our analysis. Third, part of the fiscal proceeds from OCS production serves as a funding source for environmental enhancements through the Land and Water Conservation Fund. Replacement fuel from private or foreign sources under the NSO does not support such efforts. An expanded discussion of some of these impacts is included in the section entitled Unmonetized Impacts.

The larger message of the discussion in the Net Social Value section is that a careful effort to assess the full range of environmental and social effects of the program indicates that they are not a burden imposed by the program and in fact appear to reinforce its other benefits.

Net Benefits Derived from a Program Area

The last stage in the Net Benefits analysis is to add the net consumer surplus to the NSV. This is a surplus primarily because of the societal benefits derived from lower resource prices, and it is a net value because lost domestic producer surplus that would have been generated under the NSO at higher resource prices is deducted. Virtually all of the increase in net consumer surplus from the program occurs because the added OCS oil and gas production lowers the price consumers pay for imports of oil and gas products compared to the NSO situation. Only a small fraction (i.e., 0.52%) of the net consumer surplus is associated directly with the added OCS production. This is the case primarily because the added OCS production supplies only a small fraction of total domestic consumption. The measure of net consumer surplus is calculated using the MarketSim software model.

Estimation of Consumer Surplus in MarketSim

To assess changes in the welfare of U.S. consumers under a given E&D scenario, MarketSim estimates the change in consumer surplus for each of the end-use energy markets included in the model. For a given energy source, changes in consumer surplus occur as a result of changes in both price and quantity relative to baseline conditions. In the OCS case the consumer surplus gains come almost entirely from the price reduction or pecuniary effects of increasing OCS oil and gas production. For that reason it is important to measure that change as accurately as possible. In addition to the direct effect of an increase in supply (rightward shift of the supply curve) measured by the own-price elasticity in the oil and the gas markets, MarketSim incorporates two other useful relationships in estimating this pecuniary gain.

First, the proposed Five Year Program would increase the amount of offshore oil and gas production supplied to the economy. The new oil and gas supply will affect other segments of the U.S. energy markets which create echo effects in the oil and gas market. For example, increased offshore gas production would reduce gas price which leads to a reduction (leftward shift) in coal demand. While reduced coal demand would in turn lower the equilibrium coal price, the gas demand curve as specified in the model already includes this feedback effect. Specifically, MarketSim incorporates these indirect effects through the use of cross-price elasticity arguments in the primary (e.g., gas in this example) market demand curve which generally plays out in a smaller equilibrium gas price reduction and gas quantity increase than indicated by the own-price elasticity alone. More detail on how MarketSim handles these effects is found in the model's documentation (Industrial Economics, Inc., 2012b).

Second, in addition to price elasticity effects, MarketSim uses a technique that bases the amount of energy consumed and produced in a given year partially on the quantity consumed and produced in the prior year. That relationship is supported by two aspects of fuel demand. One is that income levels, which drive much of fuel demand, change only gradually from year to year. The other is that fuel is consumed to a large extent in conjunction with durable capital equipment to produce goods or services. Thus, in MarketSim, the existing level of income and the size of the capital stock are responsible for influencing a certain level of oil and gas consumption that is independent of resource price effects. Therefore, determination of where equilibrium resource prices settle across multiple markets, and hence estimation of changes in consumer surplus associated with the Five Year Program, involve careful consideration of market factors other than only the traditional demand and supply elasticities.

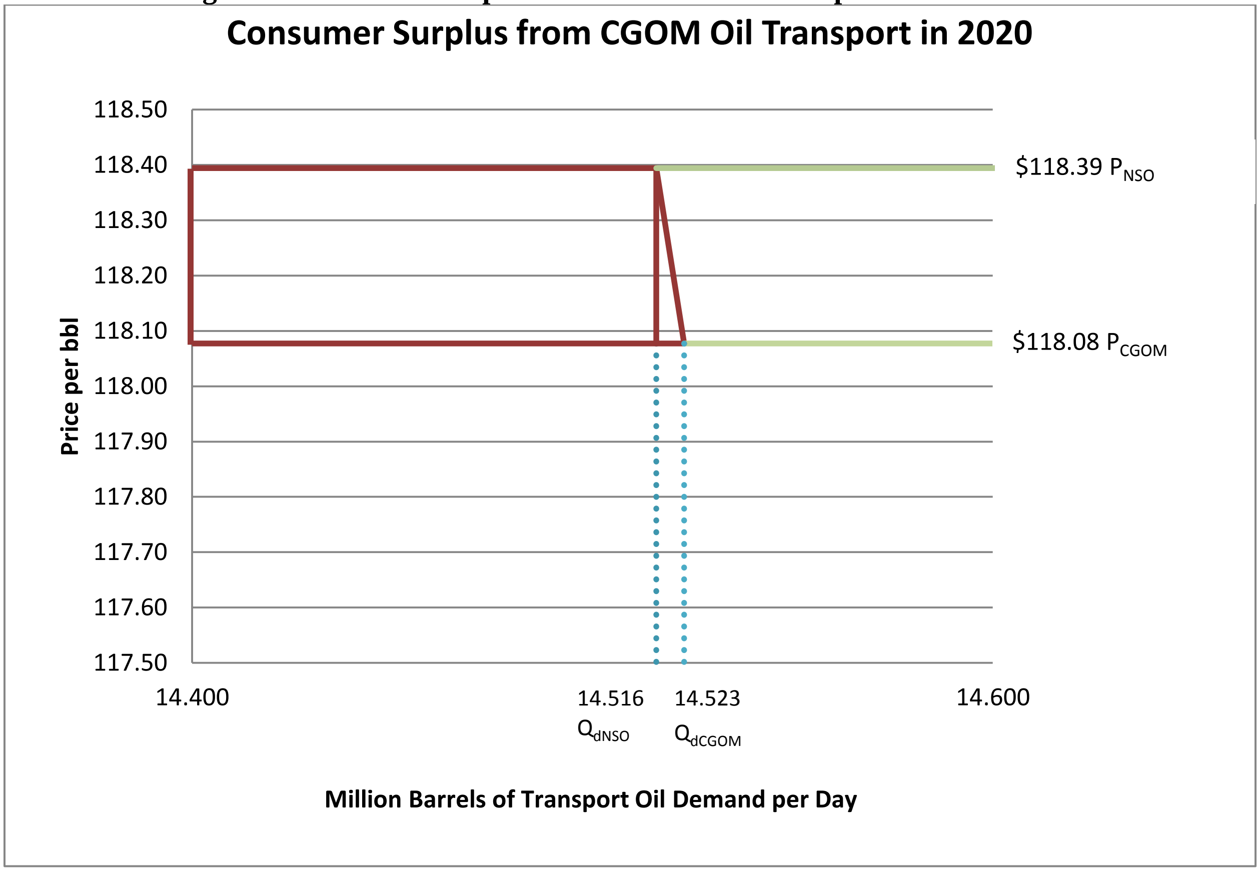
Netting out Domestic Producer Surplus

The equilibrium change in the consumer surplus of the oil, gas, coal, and electricity markets overstates the national change in social welfare. Most of this surplus is not a net gain to society as a whole, but only a transfer from producer surplus. Producer surplus occurs when producers receive more than the amount they need to recover their actual and opportunity costs and hence be willing to produce and sell the good. In other words, this surplus is a measure of their economic profit. In the case of the Five Year Program, the additional OCS production lowers the market price for oil and gas, thus increasing consumer surplus. However, as prices fall, all producers receive a smaller price for every unit of production, thus lowering their producer surplus.

This Five Year Program analysis focuses on gains and losses within the U.S., so only the domestic portion of this lost producer surplus represents an offsetting loss of national welfare. To the extent that new OCS oil and gas would displace imports, all of the consumer surplus benefits which derive from the lower market price and are directly associated with this portion of domestic production represent a net consumer surplus benefit as well. Further, MarketSim computes and compiles the net consumer surplus associated with all of the non-U.S. supplied quantities of oil and gas so as to exclude these domestic producer surplus losses from the domestic consumer surplus gains attributed to the program.

To illustrate the consumer surplus calculations, the following example outlines how MarketSim calculates net domestic consumer surplus in one of the 15 sectors it models. The chart in Figure 2 shows the change in consumer surplus in the transportation sector for the amount of oil produced from the new CGOM leases under the program in 2020, outlined in red. The calculated consumer surplus has two pieces. The first piece is the benefits that derive from having a lower price being charged for every unit of consumption that would have occurred at the higher price. This piece is simply a transfer from producers to consumers. These are the pecuniary gains associated with consumer surplus. The second piece of consumer surplus is the welfare gain from the small amount of additional consumption that occurs as the result of the lower oil price. The rectangular portion of the red trapezoid is the pecuniary gains and the additional welfare gains are the triangular portion.

Figure 2: Consumer Surplus from CGOM Oil Transport in 2020



With the NSO option, the MarketSim base case oil price in 2020 is $118.39. If the CGOM sales option is selected, the new equilibrium oil price falls to $118.08. The quantity demanded in the transportation sector with the selection of the NSO and the original price of $118.39/bbl is 14.516 million barrels per day, whereas with the CGOM sales, the quantity demanded increases by 7,000 barrels per day to 14.523 million barrels.[27] The first piece of consumer surplus is found by multiplying the price change of 31 cents ($118.39 – $118.08) by the entire quantity that would have been consumed at the original price (14.516 million barrels per day) to calculate a total (undiscounted) pecuniary benefits of $4.5 million per day transferred from producers to consumers.

Since the pecuniary gains are transferred from producers to consumers, only the consumer surplus gain on foreign production belongs in the domestic Net Benefit value. To exclude the producer surplus losses on domestic production from the pecuniary gains, MarketSim uses the percentage of U.S. oil consumption projected to be filled by foreign sources in 2020. Continuing the example for 2020, MarketSim with the new CGOM production under the program anticipates that 52% of U.S. oil consumption will be provided by non-U.S. sources, meaning that 7.55 million barrels per day (0.52*14.516) come from outside the U.S. and the remaining 6.97 million barrels per day come from domestic production. To calculate the net domestic benefit from the new CGOM production, MarketSim multiplies the equilibrium price change for that year only by

27 The total increase in CGOM production in 2020 in all sectors is approximately 163,000 barrels per day.

foreign production resulting in a domestic pecuniary gain of $2.34 million per day (7.55*0.31).

The welfare gain or triangle portion of consumer surplus is a complete benefit to the U.S. The triangle piece of consumer surplus equals one-half the change in price (31 cents) times by the additional quantity consumed with CGOM (14.523-14.516 = 0.007), or $1,085 [(0.31*.007)/2]. In this example, the net domestic consumer surplus benefit is $2.342 per day or $854.5 million (about $675 million present value in 2012) attributable to new production in 2020 in the CGOM resulting from the Proposed Final Program.

The net domestic consumer surplus measures from production due to the program, aggregated over all the program years and consumption sectors, are shown in Table 5 for each of the program areas at the three sets of stipulated resource price levels.

Table 5: Net Domestic Consumer Surplus

	Net Domestic Consumer Surplus $ Billions*		
	Low Price	**Mid-Price**	**High Price**
Central GOM	19.37	35.14	44.52
Western GOM	5.08	8.32	10.28
Eastern GOM	**	0.37	0.58
Chukchi Sea	2.66	7.54	25.00
Beaufort Sea	1.03	1.51	5.54
Cook Inlet	0.57	0.59	1.39

All values are discounted at a real discount rate of 3 percent.
* The low-price case represents a scenario under which inflation-adjusted prices are $60 per barrel for oil and $4.27 per mcf for natural gas throughout the life of the program. Prices for the mid-price case are $110 per barrel and $7.83 per mcf. Prices for the high-price case are $160 per barrel and $11.39 per mcf.
** Given current information, no production is expected from the Eastern GOM Program Area at the low-price case, whether from one or two sales; therefore consumer surplus is assumed to be zero.

As we've discussed, consumer surplus is driven by resource price changes as a result of adding new OCS leasing. Since oil prices are determined by the world market, OCS leasing does not have a large impact on prices. In fact, the greatest oil price change in any one year is $1.17[28] as a result of the new production. Even though this price change is small, to calculate the consumer surplus for the program, it is multiplied by every imported barrel domestically consumed (9.82 MMbbl/day)[29] which results in the large amounts of consumer surplus.[30]

Finally, it may appear at first glance that our inclusion of consumer surplus in the measure of net benefits results in an overestimation of program welfare to U.S. citizens,

28 In year 18 of the mid-price case of $110/bbl, this represents only a 1% price drop from the baseline.
29 Calculated in year 18 of the mid-price case of $110/bbl.
30 For more detail, see the Industrial Economics, Inc., 2012b, BOEM 2012-024.

by inadvertently including that part of consumer surplus which is associated with the export of refined petroleum products. But, that observation would be incorrect. The Net Benefit measures rely heavily for inputs on Energy Information Agency (EIA) data outputs and definitions, which are directly employed in MarketSim. In the EIA market accounts, and hence in these calculations, the demand for oil and gas for export (almost all of which is for refined products as opposed to crude oil) is not included on the U.S. market demand side, but instead is on the supply side. In that sense, market demand is purely domestic demand for oil and gas. Thus, as a result of the omission of exported oil refined products from domestic demand in both the EIA output tables and hence in the model calculations, the Net Benefits analysis properly reflects the consumer surplus only for U.S. citizens from production of OCS crude oil.

Net Benefits Summary for All Program Areas

The sum of the NSV and the net domestic consumer surplus benefits constitutes the total net benefits associated with the program area resources projected to be leased, discovered, and produced in the Five Year Program. Figure 3 illustrates each step in this process using the mid-price case calculations for Central GOM program area in the same format as Figure 1 in the *Methodology* section.

Figure 3: Net Benefits Analysis Result for Central GOM Mid-Price Case ($ billions) *

Anticipated Production **3.77 BBO** **16.41 tcf** (Table 9)	x	Assumed Oil and Gas Price Levels **$110/bbl and $7.83/mcf (**Table 8**)**	**=**	Gross Revenue **275.66****
Gross Revenue **275.66****	-	Private Costs of Program **122.07****	=	Net Economic Value (NEV) **153.59** (Table 1)
NEV **153.59 (**Table 1**)**	-	Environmental and Social Costs of Program Proposal **5.94** (Table 4) *less* Environmental and Social Costs of Energy Substitutes (Selection of the No Sale Option) **17.43** (Table 4) *equals* **Net Environmental and Social Costs** **-11.49 (**Table 4**)**	=	Net Social Value (NSV) **165.08 (**Table 6**)**
NSV **165.08**	+	Consumer Surplus Benefits *less* Lost Domestic Producer Surplus Benefits **= 35.14**	=	Net Benefits **200.23**
*All values are discounted at a real discount rate of 3 percent. **From internal model calculations				

In this case the external costs from the No Sale Option exceed those under the recommended option, so the net environmental and social effects add benefits equal to about 7 percent to the NEV of the proposed program. The estimated net domestic consumer surplus from the pecuniary effects of the program, mostly from lower gas prices, adds benefits equal to about 23 percent of that NEV.

Table 6 shows the estimates of these components of the Net Benefit analysis for all the available program areas in the Proposed Final Program options and the EIS alternatives for each of the three price cases.

Table 6: Net Benefits

	Net Social Value			Net Domestic Consumer Surplus			Net Benefits		
	($ billions)*								
	Low Price	**Mid-Price**	**High Price**	**Low Price**	**Mid-Price**	**High Price**	**Low Price**	**Mid-Price**	**High Price**
Central GOM	43.27	165.08	300.48	19.37	35.14	44.52	62.64	200.23	344.99
Western GOM	11.77	41.26	72.19	5.08	8.32	10.28	16.83	49.59	82.47
Eastern GOM	**	2.35	5.42	**	0.37	0.58	**	2.73	6.00
Chukchi Sea	5.22	31.41	136.25	2.66	7.54	25.00	7.88	38.95	161.26
Beaufort Sea	0.18	4.25	18.84	1.03	1.51	5.54	1.20	5.75	24.38
Cook Inlet	1.58	3.77	12.39	0.57	0.59	1.39	2.15	4.37	13.78

All values are discounted at a real discount rate of 3 percent.
* The low-price case represents a scenario under which inflation-adjusted prices are $60 per barrel for oil and $4.27 per mcf for natural gas throughout the life of the program. Prices for the mid-price case are $110 per barrel and $7.83 per mcf. Prices for the high-price case are $160 per barrel and $11.39 per mcf.
** Given current information, no production is expected from the Eastern GOM Program Area at the low-price case, whether from one or two sales; therefore net benefits are assumed to be zero. If exploration occurs, net benefits could be either negative—if no production results—or positive—if successful exploration leads to production. The estimated value of Eastern GOM resources is highly sensitive to changes in information, so placing a second sale on the schedule would provide flexibility to adapt to such changes.

Revisions for the Proposed Final Program Analysis

Numerous changes were made to the Net Benefits analysis for the Proposed Final Program analysis. One change to the entire analysis was the change in discount rate from a nominal seven percent to a real three percent. Upon further consideration of OMB Circular A-4, BOEM determined that the three percent social discount rate was more applicable for our analyses than the seven percent private rate. This caused all the values in the Net Benefits analysis to increase as future values were not discounted as greatly as they were previously. To make cost assumptions consistent with the flat real price scenarios, the Proposed Final Program analysis eliminated the three percent inflation that was used in the Proposed Program and now assumes zero inflation.

There were also adjustments made to different pieces of the analysis. The most important of these changes are discussed below.

Net Economic Value

BOEM determined that an adjustment factor should be included to take into account foreign profits that would not be spent domestically. As described in the Net Economic Value Derived from a Program Area section, BOEM assumed that five percent of the NEV would flow outside the U.S. and thus deducted it from our analysis. See the latter part of the section entitled Net Economic Value Derived from a Program Area for the rationale behind this assumption.

Environmental and Social Costs
The oil spill rates used in the environmental and social costs calculations from the OECM were changed to consider historical data from 1996-2010. This new study period includes recent trends and makes the Proposed Final Program analysis consistent with the Programmatic EIS.

The air emission factors were updated for the OECM. These new factors were based on a more in-depth analysis of the air quality data. In addition, the model now also calculates round-trip emissions for tankers carrying both imports and Alaskan oil to the continental U.S. The model also includes separate emissions factors to account for differences in impacts between platforms and caissons. Tables of the emissions factors are included in the OECM documentation (Industrial Economics, Inc. et al., 2012a).

Consumer Surplus
The MarketSim model was adjusted to net out all consumer surplus that represents a transfer from domestic producer surplus for each of the modeled fuels. This is discussed in the section titled Netting out Domestic Producer Surplus.

The MarketSim documentation is being published along with this document. The documentation provides more technical information on the elasticities and how price changes, energy market substitutions, and reduced demand are calculated (Industrial Economics, Inc., 2012b).

Unmonetized Impacts

The Net Benefits analysis captures the important costs and benefits associated with new OCS leasing that can be reliably estimated. However, there are other potential impacts that cannot be monetized which are discussed below.

Greenhouse Gas Emissions

The OECM monetizes air emissions factors for six different pollutants (NO_x, SO_x, PM_{10}, $PM_{2.5}$, CO, and VOCs), but it does not apply a monetary value on the damages of greenhouse gas (GHG) emissions. The model does calculate the level of emissions that would be emitted under both the program and the NSOs for carbon dioxide, methane, and nitrous oxide. Most of the GHG effect will occur with consumption rather than production of oil and gas which changes little between the program and NSO scenarios.

Moreover, because GHG are global pollutants, an estimate of discharges stemming from the NSO includes emissions from the production of oil and gas that is imported to the U.S. and from the round-trip tanker voyages that are necessary to transport the oil to the U.S. Table 7 shows the estimates of GHG emissions by program area for the mid-price case. As shown in the table, the emissions for carbon dioxide and nitrous oxide are greater under the NSOs than from the program. However, there is more methane from the program than the NSOs. Though these impacts are not monetized, they are not identical between having an OCS program and having the impacts of the NSOs.

Table 7: Greenhouse Gas Emissions

	Program Emissions			NSO Emissions			Difference		
	thousands of tons								
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Central GOM	79,907	867	2.22	234,080	157	2.42	-154,173	711	-0.20
Western GOM	21,410	285	0.53	54,164	36	0.56	-32,755	249	-0.02
Eastern GOM (2 Sales)	615	9	0.02	2,939	2	0.03	-2,324	7	-0.01
Chukchi Sea	4,324	28	0.11	57,760	40	0.62	-53,436	-12	-0.51
Beaufort Sea	1,485	11	0.03	11,570	8	0.12	-10,086	3	-0.09
Cook Inlet	760	6	0.02	5,240	4	0.06	-4,480	2	-0.04

* These values are the OECM results for the mid-price case with prices of $110 per barrel and $7.83 per mcf.

Unmonetized Costs

Passive Use Values

In general, the Net Benefits analysis includes cost estimates of many types of use values, but does not include some values that would be associated as nonuse or passive use values. Evidence of nonuse values can be found in the trade-offs people make to protect or enhance environmental resources that they do not use. Nonuse or passive use values exist under both the program and under the energy substitutes that would be necessary under the NSO.

Within the Net Benefits analysis, certain passive-use or nonuse values are not qualitatively captured. The various types of nonuse values are:

- Option value means that an individual's current value includes the desire to preserve the opportunity to use a resource in the future.

- Bequest value refers to an individual's value for having an environmental resource available for his or her children and grandchildren to experience. It is based on the desire to make a current sacrifice to raise the well-being of one's descendants. Bequest value is not necessarily equivalent to the value of any information gained as a result of delaying leasing activities.

- Existence value means that an individual's utility may be increased by the knowledge of the existence of an environmental resource, even though the individual has no current or potential direct use of the resource.

Altruistic value occurs out of one individual's concern for another. A large body of literature discusses studies of these values. However, the extent to which these estimates are transferrable to the BOEM context is probably quite limited. The values were developed using stated preference techniques and the results from such analysis are often highly dependent on the resource and specific context (which would include resource conditions, possible improvements or degradation as a result of policy changes, payment vehicles, etc.). If one were interested in evaluating the extent to which households or individuals hold nonuse values (or a bequest value in particular) for OCS oil and gas resources, original empirical research would need to be conducted because a benefits transfer approach would not be appropriate given the importance of the specific context for stated preference studies. Total economic value studies (nonuse values are part of total economic value) are time consuming and expensive to conduct. These types of studies are most appropriate to conduct in situations where the resources under consideration are unique, where a set of defined changes to the resource can be easily identified, and where the resource(s) are not typically bought and sold in markets. It is not clear this is the case for OCS resources. OCS oil and gas resources are not unique and they are readily bought and sold in markets.

More discussion on the ecological components not included in the Net Benefits analysis is in the section titled OECM Ecological Modeling.

Catastrophic Oil Spills
Given the difficulties in determining expected costs of a catastrophic oil spill because of the very unlikely nature of an event, the estimated impacts are not included in the Net Benefits analysis. In order to provide some sense of the potential impacts that could be derived from a catastrophic spill, BOEM quantifies the risk and monetizes the costs below in the section titled Catastrophic Oil Spill Analysis.

Unmonetized Benefits

The OECM does not include any values of certain benefits from OCS oil and gas activities because a credible assessment of a monetized impact cannot be made in the areas of geographic interest owing to a lack of available data. While an important component of the monetized benefits is the avoided environmental and social costs of production from the OCS, rather than from any of the NSOs, there may be additional environmental and social benefits stemming from oil and gas leasing activity that impact stakeholders. Several categories of these unmonetized benefits can be evaluated and are discussed qualitatively below.

Recreational Fishing and Diving
Oil and gas platforms provide recreational and commercial fishing and diving boats with easily identifiable areas with which to navigate to in open waters. In the GOM, where the seafloor consists mostly of soft mud and silt, artificial reefs and platforms can provide additional hard-substrate areas for a variety of benthic species (Lindquist, Shaw, and Hernandez, 2005). These platform and artificial reefs can serve as fish hiding spots or as grounds for increased predation, support important nursery environments for certain types of fish, and may increase the abundance, density, and composition of fish species around platforms as compared to natural reef sites (Stanley and Wilson, 2000).

Gulf Coast states have recognized the potential importance of such aquatic structures to marine species and local activities. The artificial reef programs in these states, as part of the Rigs-to-Reefs (RTR) program, have worked to facilitate the permitting, navigational requirements, and liability transfer for decommissioned and reefed rigs in federal and state OCS waters. The reduction in pressure on natural surrounding reefs and the impact on local industries, and to a certain extent, the greater economy, illustrates the potential environmental and social benefits artificial reefs may provide. The leasing from this Five

Year Program is expected to increase the number of platforms in the GOM, providing increased gathering areas for commercial and recreational fishermen and steering reefing activities towards artificial reef locations that tend to decrease navigational and commercial fishing burdens while increasing the attractiveness of sites for recreational and commercial use.

Natural Oil Seepage

Naturally occurring oil seeps are a significant source of hydrocarbon gas (methane) and liquid (oil and tar) leaking into the environment. Natural seeps are fed by pools of oil and natural gas that form under sedimentary rock layers of the Earth's crust. Oil and gas is pushed to the surface by pressure from the resulting rock layers and these seeps occur on land and in marine environments. Oil leaking from hydrocarbon seeps can be a large source of the total oil entering into the environment every year, and some of the greatest hydrocarbon marine seepage areas throughout the world are located off the coasts of the United States, most notably in the Pacific (Santa Barbara Channel) and the Gulf of Mexico (Macdonald, Ackleson, Duckworth, and Brooks, 1993).

Man-made processes involved with oil and gas exploration and development may potentially reduce the amount of hydrocarbons naturally seeping into the environment by reducing the reservoir pressure beneath natural seeps (Homafius, Quigley, and Luyendyk, 1999). The effects of such a reduction in pressure from reservoir development and ultimately natural seepage could have significant positive effects on water quality which are likely large enough to offset any lost ecosystem value of natural seeps.

National Energy Security

Over the last fifty years, U.S. oil and gas demand, supply, and prices have increasingly shaped U.S. national energy policy concerns and national security issues. As crude oil is used as a source of energy for many goods, services, and economic activities throughout the U.S. economy, supply disruptions and increases in energy prices are felt by nearly all U.S. consumers.

Concerns over energy security stem from the importance crude oil and more recently, natural gas, have on the functionality of U.S. economic markets and the energy supply disruptions that can frequently occur due to the characteristics and behavior of the global crude oil supply market. The externalities associated with oil supply disruptions – economic losses in GDP and economic activity – have been shown to be greater for imported oil than domestically produced oil. Increased domestic oil production can boost the share of stable supplies in the world market while increased oil imports, often from unstable regions, can have the opposite effect (Brown and Huntington, 2010). Increased oil and gas production from the federal OCS can help mitigate the impact of supply disruptions and spikes in oil prices on the U.S. economy, mitigating economic downturns as well as the amount of U.S. dollars sent overseas from purchases of crude oil imports.

U.S. Trade Deficit

In recent years, a growing percentage of the U.S. trade deficit has been related to energy expenditures. As crude oil is an essential part of many goods, services, and economic activities, sustained high energy prices can alter the composition of the U.S. trade deficit (Jackson, 2011). Increases in energy expenditures represent an increase in overseas payments to foreign producers for imported oil and a transfer of wealth from the U.S. to oil producers. Large expenditures on crude oil imports in the face of recent high energy prices can stifle economic activity and slow down domestic economic growth, as well as impact the rate of U.S. inflation and reduce the real discretionary incomes of U.S. consumers (Jackson, 2011). Domestic production of oil from the OCS reduces the amount of oil that must be imported from abroad, and because oil demand tends to be inelastic thereby curtails the effect high energy expenditures may have on the U.S trade deficit.

Assumptions and Input Data

Considerable uncertainty surrounds future production from the OCS and resulting impacts on the economy. A broad range of future conditions can result from a lease sale schedule. To be useful an analysis must be both specific and realistic, which is difficult in the face of uncertainty. Price expectations play an especially important role in estimating the value of the proposed program. For instance, the industry will be much more likely to develop hydrocarbon resources in frontier areas if it expects future oil prices to remain high. Despite a broad range of future conditions that can result from activities associated with the program, BOEM strives for consistency by using standard input assumptions in calculating each component of the economic analysis. The analysis in the Programmatic EIS that accompanies the program decision document uses the same set of assumptions as the Net Benefits analysis. Six subsets make up the full assumption set for the economic analysis.

For the proposed program analysis, the assumption set is:

- oil and natural gas prices
- finding and extraction cost assumptions
- the discount rate
- anticipated production
- production profiles
- exploration and development scenarios

Oil and Natural Gas Price-Level Assumptions

Leasing from the 2012-2017 program enables new exploration, development, and production activity for a period of 40 to 50 years. Although oil prices can experience a high degree of volatility during this period, BOEM assumes three level-price scenarios in which the inflation-adjusted, or “real,” prices for oil and gas remain constant to allow decision makers to more easily envision and compare the range of possible production, benefits, and costs if prices rise or fall. Use of variable prices in the analysis would make it difficult for the decision makers to separate out the impacts of forecast price changes from the underlying differences in program areas. For this reason, the proposed program analysis includes resource and net benefit estimates for each of the three level price scenarios shown in Table 8.

Table 8: Proposed Program Price Scenarios

	Oil (per bbl)	Gas (per mcf)
Low Price	$60	$4.27
Mid-Price	$110	$7.83
High Price	$160	$11.39

Cost Assumptions

If resource prices increase significantly, their impact on oil and gas activities are not immediately felt due to long lead times needed to explore for resources and new infrastructure required to support higher activity levels. In addition, large increases in resource prices create additional competition for existing drilling rigs and investment dollars from other parts of the world which raises the cost of exploration, development, and production which in turn dampens the production boost from increased resource prices. Based on a historical analysis, BOEM assumes a cost-price elasticity of 0.5 to calculate the NEV for each planning area price scenario. In other words, BOEM assumes the costs of oil and gas exploration and development change in half the proportion as the change in oil prices across the scenarios (e.g., $60/bbl oil prices are 45% lower than $110/bbl oil prices, so costs that are 22.5% lower in the $60/bbl scenario than the costs used in the $110/bbl oil scenario are used).

Discount Rate

Based on guidance from OMB Circular A-4, a real discount rate of three percent is used for determining the present value of all Net Benefit calculations. A discount rate of three percent is considered the appropriate rate by OMB for the "social rate of time preference." This simply means the rate at which "society" discounts future consumption flows to their present value. All values are discounted back to 2012 dollars. In the case of determining applicable economically recoverable resource amounts, various private rates of return were employed consistent with the level of risk in each program area to estimate the amount of oil and gas resources that would be profitable for the private sector to lease and explore.

Anticipated Production

Anticipated production is the estimated quantity of oil and natural gas expected to be produced as a result of the lease sales included in the proposed program. The Net Benefit analysis as summarized in the proposed program document at part IV.C, *Comparative Analysis of OCS Planning Areas,* uses anticipated production as a key empirical input to calculate the NEV of future production streams.

Undiscovered economically recoverable resource (UERR) estimates from the 2011 National Assessment form the basis for anticipated proposed program OCS production. The Five Year Program's incomplete exploration activity over entire planning areas is insufficient to discover the entire resource endowment. The National Assessment models the undiscovered, technically and economically recoverable oil and natural gas resources located outside of known OCS oil and gas fields. The assessment considers recent geophysical, geological, technological, and economic information and uses a play analysis approach to resource appraisal.[31]

In mature areas like much of the GOM, BOEM bases an estimate of the anticipated production share of the UERR under the program on sale specific production trends and recent leasing and drilling activity. BOEM also considers BOEM's internal 10-year production forecast which includes reserves, announced finds and expected production from undiscovered resources. The GOM has experienced a downturn in leasing and drilling activity over the past five-plus years, especially in the Western GOM. This decline in activity led us to adjust downward the anticipated GOM production from this proposed program compared to the 2007-2012 program. BOEM expects this program to yield anticipated production of about fourteen percent of the UERR in the Central GOM and about seven percent in the Western GOM.

In frontier areas like the Alaska Arctic, BOEM bases anticipated production on judgments regarding the level of industry leasing and exploration activities that could lead to the discovery and development of new commercial fields consistent with the corresponding price assumptions. The estimates shown in Table 9 for Alaska Arctic areas are conditional on the assumption that initial development occurs on current leases and future OCS projects are produced through this infrastructure. With that proviso, BOEM expects this program to yield anticipated production of about eight percent of the UERR in the Chukchi Sea and about four percent in the Beaufort Sea.

Table 9 shows anticipated production estimates for program areas included in the Proposed Final Program decision document.

31 See http://www.boem.gov/Oil-and-Gas-Energy-Program/Resource-Evaluation/Resource-Assessment/Methodology.aspx for a complete description of the national resource assessment methodology.

Table 9: Proposed Program Production Estimates*

	Oil (billion barrels)			Gas (trillion cubic feet)			BBOE		
	Low Price	Mid-Price	High Price	Low Price	Mid-Price	High Price	Low Price	Mid-Price	High Price
Central GOM	2.24	3.77	4.34	9.47	16.41	19.07	3.92	6.69	7.73
Western GOM	0.56	0.86	0.97	2.63	4.07	4.59	1.03	1.58	1.79
Eastern GOM**	0.00	0.05	0.07	0.00	0.11	0.16	0.00	0.07	0.10
Chukchi Sea	0.50	1.00	2.15	0.00	2.50	8.00	0.50	1.44	3.57
Beaufort Sea	0.20	0.20	0.40	0.00	0.50	2.20	0.20	0.29	0.79
Cook Inlet	0.10	0.10	0.20	0.00	0.04	0.68	0.10	0.11	0.32

* After publication of the January 2009 Draft Proposed Program decision document, BOEM completed a subsequent resource assessment (2011 assessment) resulting in revised estimates of unleased, undiscovered economically recoverable resources. The new estimates are reflected in the anticipated production numbers in this table. The low-price case represents a scenario under which inflation-adjusted prices are $60 per barrel for oil and $4.27 per mcf for natural gas throughout the life of the program. Prices for the mid-price case are $110 per barrel and $7.83 per mcf. Prices for the high-price case are $160 per barrel and $11.39 per mcf.

** Current information does not indicate that the number of sales would affect anticipated production for the Eastern GOM. The two-sale option allows the Secretary to consider any new information that might arise from exploration on existing leases subsequent to his decision on the program, when deciding whether to hold a second sale.

Production Profiles

Production profiles or schedules show the distribution of anticipated production by year over the life of program related activity in each program area. Generally, production begins earlier in established, shallower, near-shore areas in the GOM. Deepwater and frontier areas production schedules begin later and the activity tends to stretch over longer periods. BOEM uses time periods of either 40 or 50-years for each lease sale to model the E&D activity. While production related to leasing in the 2012-2017 program may extend beyond the activity period with secondary recovery techniques, new technology, or growth in reserve/resource estimates, the models provide results for 40 years in the GOM and 50 years in Alaska following a lease sale in this proposed program.

Exploration and Development Scenarios

Associated with various production levels in each program area are the activities required for exploration and development of OCS oil and gas resources. The list of these activities and facilities is called an exploration and development (E&D) scenario. These factors of production and activities yield the hydrocarbon resources and cause environmental and social impacts. The timing of production and revenue streams as well as social and environmental cost factors depend on the specified schedule of the various E&D activities. Table 10 shows the summary level E&D scenario for the Mid-price case attributable to each program area. The E&D scenarios for the Low- and High-price cases include corresponding though not linear well, facility, and pipeline activity levels.

Table 10: Proposed Program E&D Scenario
Mid-Price Case $110/bbl, $7.83/Mcf

	Gulf of Mexico			Alaska		
	Central	**Western**	**Eastern**	**Cook Inlet**	**Beaufort Sea**	**Chukchi Sea**
No. of sales	5	5	2	1	1	1
Anticipated Production (BBOE)	6.69	1.58	0.07	0.11	0.29	1.44
Years of activity	40	40	40	40	50	50
Exploration & Delineation Wells	1,388	380	12	4	6	12
Development & Production Wells	1,725	476	10	42	40	100
Subsea	9	1	1	0	10	36
Platforms	274	86	0	1	1	2
Pipeline miles	3,979	1,149	37	50	60	100

Catastrophic Oil Spill Analysis

In the aftermath of the *Deepwater Horizon* event in April 2010, BOEM is making consideration of the potential impact of low-probability/high-consequence oil spills more explicit in its assessments of future exploration, development, and production activities on the OCS. A decision as to whether or not to proceed with proposed lease sales necessarily carries with it the risk, however slight, of a catastrophic oil spill, regardless of the decision. This document primarily addresses environmental and social resources and activities that could be affected by a catastrophic oil spill resulting from OCS oil and gas activities anticipated from proposed lease sales. However, a decision not to lease also carries with it the risk of a catastrophic oil spill resulting from tankers carrying imported oil to replace OCS production if the NSO is selected for one or more program areas.

The potential costs to society in quantitative or monetary terms are highly dependent upon the circumstances of the event and its aftermath. The wide and unpredictable nature of factors that alone or in combination can influence a catastrophic oil spill's impact include, but are not limited to, human response, spill location, reservoir size and complexity, response and containment capabilities, meteorological conditions, and the type of oil spilled. This makes determining the severity of a large oil spill's impact and makes the quantification of costs far less reliable than other measures developed for the Net Benefits analysis. Nevertheless, BOEM estimates the social and environmental costs of the EIS catastrophic spill sizes and presents them separately from the results of the Net Benefits analysis. The assumptions reflect an unpropitious scenario with regard to location and season when the social and environmental impacts are likely to be higher.

A "catastrophic" spill is not expected, and would be considered well outside the normal range of probability despite the inherent risks of oil production-related activities expected from the Five Year Program. Recently implemented safeguards including additional subsea BOP testing, required second downhole mechanical barriers, well containment systems and additional regulatory oversight make such an event much less likely. Given the range of variables that can affect the severity of a catastrophic oil spill, the same initial event could cause very different impact trajectories, making it difficult to predict what the consequences of future events would be other than to say they *could be* very large in human, economic, and environmental terms. The potential for "catastrophe" is not solely a function of the quantity of oil released, as the uncontrolled release of a certain size at a particular location even within the same program area and at a particular time of year could have more significant economic or environmental effects than a release of considerably more barrels under different circumstances relating to precise location and season (Industrial Economics, Inc., 2012d).

Approach for Quantifying the Possible Effects of a Catastrophic Spill

This analysis identifies and estimates the environmental and social costs should there be a potentially catastrophic oil spill in any of the BOEM planning areas. This section supplements the Section 18 Net Benefits analysis found earlier in this document and in part IV of Proposed Final Program decision document where the costs of expected smaller sized oil spills are considered. Additional analysis related to an inventory of resources that could potentially be affected by a catastrophic discharge event can be found in the Programmatic EIS (U.S. Department of the Interior/BOEM, 2012a) and the supporting document *Inventory of Environmental and Social Resource Categories Along the U.S. Coast* (Industrial Economics, Inc., 2012d).

For purposes of this analysis, a catastrophic OCS event is defined as any high-volume, long-duration oil spill from a well blow-out, regardless of its cause (e.g., a hurricane, human error, terrorism). In this analysis, to capture some of the worst possible effects, a catastrophic spill is placed close to vulnerable assets at a point in time when weather and other factors inhibit prompt containment and cleanup efforts. The National Oil and Hazardous Substances Pollution Contingency Plan further defines such a catastrophic event as a "spill of national significance," or one that "due to its severity, size, location, actual or potential impact on the public health and welfare or the environment, or the necessary response effort, is so complex that it requires extraordinary coordination of federal, state, local, and responsible party resources to contain and clean up the discharge" (40 CFR 300, Appendix E) (Industrial Economics, Inc., 2012d).

This assessment of the potential costs of a catastrophic oil spill of national significance does not mean that a catastrophic event can be pinned down to an expected cost measure comparable to other values estimated for OCS activity. With a few OCS catastrophic oil spill data points, statistically predicting a catastrophic blowout event that produces an oil spill consistent with the programmatic analysis for the EIS and data from both U.S. OCS and international offshore drilling history is beset with unknowns. An effort to calculate the frequency of a catastrophic oil spill is described in the section Detailed Frequency Calculations and discussed in the section Statistical Frequency of a Catastrophic Oil Spill. While the risk is not zero, a catastrophic spill is anticipated neither from this Five Year Program nor from the energy substitutes the market would supply if the NSO were selected in any or all program areas. Consistent with Executive Order 13547, *Stewardship of the Ocean, Our Coasts, and the Great Lakes* BOEM uses "(2.iv) the best available science and knowledge to inform decisions affecting the ocean, our coasts, and the Great Lakes . . ." This analysis attempts to estimate the costs of a hypothetical catastrophic spill in each of the Five Year Program areas.

OCS Catastrophic Oil Spill Sizes

For consideration of potential environmental and social costs that might result from catastrophic events, BOEM adopts the hypothetical catastrophic oil spill size specifications, by program area, used for the Programmatic EIS (U.S. Department of the Interior/BOEM, 2012a). The catastrophic spill analysis estimates the social and environmental costs for both a low and high volume catastrophic spill occurring in a vulnerable location and season for each program area. The defined spill sizes, duration, and important factors are shown in Table 11.

Table 11: Catastrophic Oil Spill Size Specifications[32]
From the Five Year Programmatic DEIS
(U.S. Department of the Interior/BOEM, 2012a)[33]
(GOM Program Areas split between shallow and deep areas)[34]

Program Area	Volume (million bbl)	Duration (days)	Factors Affecting Duration
Central and Western Gulf of Mexico, (shallow)[35]	0.9–3.0	30–90	Water depth
Central, Western, Eastern Gulf of Mexico (deep)[36]	2.7–7.2	90–120	Water depth
Chukchi Sea	1.4–2.2	40–75	Timing relative to ice-free season and/or availability of rig to drill relief well
Beaufort Sea	1.7–3.9	60–300	
Cook Inlet	0.075–0.125	50–80	Availability of rig to drill relief well

The Gulf of Mexico OCS region has specified the discharge rate, volume of a spill, and the extent and duration for a catastrophic spill event for both shallow and deep water (in part) based on information gathered and estimates developed for the Ixtoc (1979) and the *Deepwater Horizon* (2010) events. The Alaska OCS region has developed a catastrophic oil spill scenario based on a reasonable, maximum flow rate for each OCS program area, taking into consideration existing geologic conditions and information from well logs. The number of days until a hypothetical blowout and resulting oil spill could be contained was also specified. These are discharge volumes and spill duration do not account for decreases in volume from containment or response operations (U.S. Department of the Interior/BOEM, 2012a).

32 The catastrophic oil spill parameters developed in the Programmatic EIS are intended to provide a scenario for a low-probability event with the potential for catastrophic consequences (U.S. Department of the Interior/BOEM, 2012a). Past oil spills that may be relevant include the non-OCS program related Exxon Valdez oil spill of 262,000 bbl in Prince William Sound of south central Alaska and the Ixtoc oil spill of 3,500,000 bbl in Mexican waters in western GOM as well as the OCS *Deepwater Horizon* event of 4,900,000 bbl in the northern GOM (McNutt et al., 2011).

33 Modified Table 4.4.2-2: Catastrophic Discharge Event Assumptions (U.S. Department of the Interior/BOEM, 2012a)

34 For consistency with the E&D scenario data, this analysis defines deepwater for the GOM as greater than 200 meters (654 feet). The potentially available Eastern GOM area is entirely in the deepwater. Prospective Alaska program area acreage is entirely in shallow water depths.

35 For this analysis, an uncontrolled flow rate of 30,000 barrels per day is specified for a catastrophic oil spill from a blowout in shallow water. This rate is based upon the results of well tests in shallow water and the maximum flow rate from the 1979 Ixtoc blowout and oil spill, which occurred in shallow water. In addition to the spill rate shown above, it is assumed that any remaining diesel fuel from a sunken drilling rig would also leak (U.S. Department of the Interior/BOEMRE, 2011, Section 3.1.3.1).

36 For the purposes of this analysis, an uncontrolled flow rate of 30,000-60,000 barrels per day is specified for a catastrophic blowout and oil spill in deep water. This flow rate is based on well test results, and the maximum expected flow rate of the 2010 *Deepwater Horizon* event, which occurred in deep water. In addition to the spill rate shown above, deepwater drilling rigs hold a large amount of diesel fuel (10,000-20,000 barrels). Therefore, it is assumed that any remaining diesel fuel from a sunken drilling rig would also leak and add to the spill (U.S. Department of the Interior/BOEMRE, 2011, Section 3.1.3.2).

Statistical Frequency of a Catastrophic Oil Spill

In order to calculate the *risked* social and environmental costs from a catastrophic spill that could, but is not expected to occur in this program, the BOEM developed a frequency estimate based on historical analysis of the likelihood of a well blowout that would result in an oil spill of a catastrophic size. The historical statistical frequency exceedance value used in this analysis is likely significantly higher than the actual future frequency due to the proactive actions of the government and industry to reduce the chance of another blowout and catastrophic oil spill. These risk reduction measures are discussed below in the section entitled Risk Reduction Efforts. However, absent data regarding the frequency of catastrophic oil spills under the new regulatory regime, BOEM uses historical exceedance frequency values derived from U.S. OCS drilling and blowout data from 1964-2010.[37] Even using all available historical data in the data set, there are still problems with a small sample size based on the limited number of blowouts and even smaller number of blowouts leading to oil spills. From 1964-2010 over 48,000 wells were drilled with only 283 loss of well control instances.[38] Of the loss of well control instances, only 61 resulted in an oil spill. Almost all oil spills resulting from loss of well control instances were very small. Including the *Deepwater Horizon* event, the median spill size of these 61 events is only two barrels. The frequency used in each of the program areas for both a high and low volume spill is given in Table 12.

Using the historical data, the frequency estimates are developed for the risk that there will be a loss of well control event accompanied by a spill of a certain size category. The larger the size of a spill, the smaller is the frequency of a loss of well control event producing a spill of that size or greater. Information on how these frequencies were developed is given in the section titled Detailed Frequency Calculations.

37 Despite changes in technology and the move into deeper water, rate of loss of well control incidents has remained fairly constant over this period, making it appropriate for our analysis. One likely reason for this is that as drilling challenges increase, companies develop corresponding technology to address well control and other issues.

38 As defined in BSEE regulations for incident report, Loss of Well Control means:

- Uncontrolled flow of formation or other fluids. The flow may be to an exposed formation (an underground blowout) or at the surface (a surface blowout);
- Flow through a diverter;
- Uncontrolled flow resulting from a failure of surface equipment or procedures.

See http://www.boemre.gov/incidents/blowouts.htm

Table 12: Estimated Catastrophic Oil Spill Frequency

		Approximate Frequency		Approximate Frequency 1 in X wells	
		Low Volume Spill	High Volume Spill	Low Volume Spill	High Volume Spill
Central GOM	Shallow (<200m)	0.000033	0.000024	31,000	41,000
	Deep	0.000025	0.000020	40,000	50,000
Western GOM	Shallow (<200m)	0.000033	0.000024	31,000	41,000
	Deep	0.000025	0.000020	40,000	50,000
Eastern GOM		0.000025	0.000020	40,000	50,000
Chukchi Sea		0.000029	0.000026	34,000	38,000
Beaufort Sea		0.000028	0.000023	36,000	43,000
Cook Inlet		0.000059	0.000052	17,000	19,000

*The approximate frequency estimate is based on an exceedance value. The frequency of 1 in X wells is the frequency of having a loss of well control incident and an oil spill of the catastrophic volumes defined in OCS Catastrophic Event Spill Sizes or greater.

No single type of accident automatically results in a multi-million-barrel release of oil. Greater volumes result only from a greater number of failures in redundant systems and other safeguards and from delays in stopping the flow of oil. Because each safeguard and response mechanism has its own probability of success, the cumulative probability of failure is lower for larger volumes (just as the probability of rolling a die and getting the same number 10 times in a row is much less likely than getting the same number only the first four times the die is rolled). Therefore, the “must exceed” risked cost (estimated cost times estimated probability) is greater for the lower-probability high-volume spills than for the low-volume spills.

Estimated Program Area Results

The calculated statistical frequency of a catastrophic oil spill can be used in conjunction with program area specific costs of a spill to determine the impact of a catastrophic spill. The environmental and social costs considered in this analysis are described in detail by region in the section below entitled Detailed Cost Calculations. There the seven cost categories considered: natural resource damages, subsistence harvest, recreation impacts, commercial fishing, oil and gas production, the value of life and non-fatal injury, and oil spill containment and clean-up. Using the costs described later and the statistical frequency of a catastrophic spill, the potential effects of a catastrophic oil spill are summarized in the following sections. BOEM presents three separate ways to consider the costs of a catastrophic spill: conditional costs, risked costs, and break-even costs.

Conditional Costs

The conditional costs of a catastrophic oil spill are simply the estimated costs should the spill occur. Table 13 shows the estimated spill costs of a catastrophic spill for each program area. While a catastrophic oil spill is not expected in this program, if a spill were to occur, Table 13 provides an estimate of what these costs might be. However, as discussed earlier, there are many factors that influence the effects of a catastrophic oil spill. These conditional costs vary with a program area based solely on the size of the spill, but in practice they can vary as well by specific location of the spill, season of the year, wind conditions, etc. These estimates were made using assumptions that would results in a more severe outcome than can be expected to happen at random. The components of the cost estimates for each of the program areas are discussed in the section entitled Detailed Cost Calculations.

Table 13: Conditional Catastrophic Spill Costs

		Conditional Undiscounted Spill Costs $ billions	
		Low Volume Spill	**High Volume Spill**
Central GOM	**Shallow (<200m)**	3.52	11.08
	Deep	10.00	26.19
Western GOM	**Shallow (<200m)**	3.52	11.08
	Deep	10.00	26.19
Eastern GOM		10.00	26.19
Chukchi Sea		10.07	15.75
Beaufort Sea		12.16	27.77
Cook Inlet		1.59	2.55

While Table 13 shows the conditional costs of a catastrophic oil spill, these values are not comparable to the results in the Net Benefits analysis. The Net Benefits analysis shows the discounted value of benefits expected from each program area. To be consistent with the Net Benefits analysis, the conditional spill costs should be discounted over the 40-50 year life of the program. Even discounted, conditional spill costs are not comparable since they do not represent a risked value. To discount the conditional costs, BOEM distributed the conditional cost of a spill over time based on the number of wells drilled in each program area in each year to approximate the concentration of the risk of a spill.[39] The results are then discounted back to 2012 at three percent and summed. These results are shown in Table 14.

39 Using the timing of all wells drilled in the mid-price E&D scenario.

Table 14: Discounted Conditional Catastrophic Spill Costs

		Conditional Discounted Spill Costs $ billions	
		Low Volume Spill	High Volume Spill
Central GOM	Shallow (<200m)	2.43	7.65
	Deep	6.25	16.38
Western GOM	Shallow (<200m)	2.44	7.67
	Deep	6.53	17.11
Eastern GOM		6.77	17.73
Chukchi Sea		6.15	9.62
Beaufort Sea		7.62	17.41
Cook Inlet		0.93	1.50

*All values are discounted at a real discount rate of 3 percent.

Risked Costs

While the conditional costs show valuable information on the impacts if a catastrophic spill did happen, a catastrophic spill in any of the program areas from this Five Year Program is highly unlikely. To take into consideration the chance of a catastrophic spill in making the cost estimates, BOEM uses the statistical frequencies of a catastrophic spill per well drilled from Table 12 and multiplies them by the number of wells expected to be drilled in each year, as given in the applicable E&D scenarios.[40] The resulting figures represent the expected number of catastrophic spills in a given year in each program area. This number is much less than one even if summed over all years and all program area scenarios. The expected number of catastrophic spills is then multiplied by the cost of a catastrophic spill.[41] These risked, annual costs results are discounted back to 2012 at three percent and summed to obtain the risked present value catastrophic spill costs. The magnitudes of these discounted and risked spill costs are shown in Table 15.

Table 15: Estimated Risked Catastrophic Spill Costs

		Risked Spill Costs $ billions	
		Low Volume Spill	High Volume Spill
Central GOM	Shallow (<200m)	0.12	0.28
	Deep	0.22	0.46
Western GOM	Shallow (<200m)	0.04	0.09
	Deep	0.06	0.12
Eastern GOM		0.00	0.01
Chukchi Sea		0.03	0.04
Beaufort Sea		0.01	0.02
Cook Inlet		0.00	0.00

*All values are discounted at a real discount rate of 3 percent.

40 Using all wells drilled in the mid-price E&D scenario.
41Essentially calculating the statistical "expected value" of a catastrophic oil spill.

Break-Even Analysis

There is much uncertainty surrounding both the probability of a catastrophic oil spill and the costs associated with one. Rather than looking at the costs of a catastrophic spill with only one set of assumptions on costs and on probability, its impacts can also be viewed from a "break-even" perspective. The break-even analysis shows the combination of oil spill probabilities and costs from a catastrophic oil spill at which the risked costs would cancel out the net benefits of the program.

Table 16 shows what the probability would need to be under both the low and high volume catastrophic spill scenarios, given the costs shown in Table 13, to cancel out the net benefits from the program. For example, as shown in Table 16, the probability of a catastrophic spill in the shallow water CGOM would have to be 1 in 100 wells drilled in order for the net benefits of the program to be erased by the risked cost of a catastrophic oil spill. The conservatively estimated frequency of a spill in the CGOM shallow water is 1 in approximately 30,000.

Table 16: Break Even Analysis on Spill Risk

		Approximate Probability must exceed 1 in X for risked costs to exceed Net Benefits	**Approximate Probability must exceed 1 in X for risked costs to exceed Net Benefits**
		Low Volume Spill	**High Volume Spill**
Central GOM	**Shallow (<200m)**	100	310
	Deep	60	140
Western GOM	**Shallow (<200m)**	100	320
	Deep	60	150
Eastern GOM		50	130
Chukchi Sea		20	40
Beaufort Sea		70	160
Cook Inlet		10	20

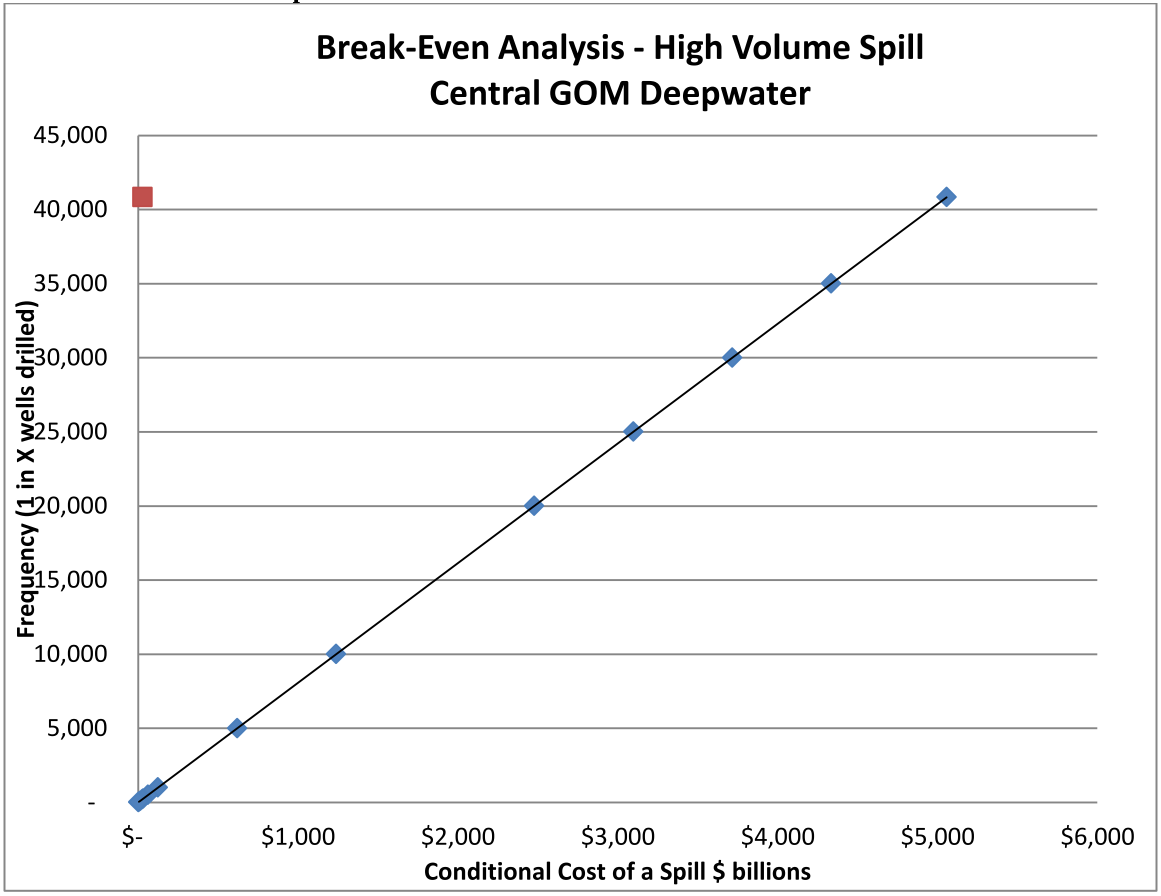
An alternate way to conduct the break-even analysis is to break-even given the calculated frequency of a spill, but varying spill costs. These results are shown in Table 17. As shown in the table, given a frequency of a catastrophic spill of a little over 1 in 30,000 wells drilled, the cost of a catastrophic spill in the CGOM shallow water would have to be over $1 trillion in order for the risked value of a spill to erase the net benefits of the area. BOEM's estimate of a catastrophic spill in shallow water CGOM is approximately $3.5 billion (as shown in Table 13).

Table 17: Break Even Analysis on Spill Costs

		Approximate Spill Costs must exceed this (in $ billions) for costs to exceed Net Benefits	Approximate Spill Costs must exceed this (in $ billions) for costs to exceed Net Benefits
		Low Volume Spill	**High Volume Spill**
Central GOM	**Shallow (<200m)**	1,100	1,450
	Deep	7,300	9,250
Western GOM	**Shallow (<200m)**	1,100	1,400
	Deep	6,900	8,700
Eastern GOM		7,700	9,800
Chukchi Sea		15,000	16,500
Beaufort Sea		6,200	6,500
Cook Inlet		2,600	2,550

In addition to considering the break-even analysis results separately on both the probability of a spill and the potential costs from the spill, graphing the two variables can clarify the improbability that the risked cost of a catastrophic oil spill would be greater than the net benefits of a program area. Figure 4 shows the breakeven set of frequency and cost points in the diagonal line for a high-volume catastrophic spill in the mid-price case of the deepwater Central GOM program area. All points below or to the right of this line show costs and frequencies where the risked cost of a spill would be greater than the net benefits. However, all the points above or to the left represent combinations of frequencies and costs which, even considering the risked value of a catastrophic oil spill, would still leave positive net benefits in the program area. The point near the y-axis is the estimated frequency (1 in approximately 40,000 wells) and the estimated cost (approximately $26 billion) for a catastrophic oil spill in the deepwater Central GOM. This point is clearly very far above the break-even line. Of course, a catastrophic oil spill is a binary event, so in the unexpected event of a catastrophic oil spill, the conditional costs in Table 13 would be the ones actually experienced. Similar graphs (not presented here) were constructed for each of the program areas, and they all show estimated costs and frequencies far to the left of the break-even line.

Figure 4:Break-Even Analysis of a High Volume Spill in the Central GOM Deepwater Compared to the Undiscounted Mid-Price Case Net Benefits



Absent a new OCS Five Year Program, the substitute energy sources also contain risk of a catastrophic event. These events are discussed in the section entitled Catastrophic Risks of the No Sale Options and the costs of a tanker spill in the GOM are described in the section entitled Estimated Cost of a Catastrophic Tanker Oil Spill.

Recent Risk Reduction Efforts

The historical statistical analysis period from 1964 to 2010 includes many regulatory, process and technological advances in the offshore oil and gas industry. Moreover, the frequency analysis of historical spill rates itself does not account for concerted efforts since the *Deepwater Horizon* event that further reduce the risk of a catastrophic spill. The programmatic EIS provide an extensive discussion on risk reduction efforts in Section 4.3.3 (U.S. Department of the Interior/BOEM, 2012a).

Industry and government have adopted significant steps to both reduce the likelihood of well control incidents and prevent an incident from developing into a catastrophic spill. These efforts address a spectrum of factors throughout the OCS exploration and development process. The Bureau of Safety and Environmental Enforcement (BSEE) has initiated a series of recent reforms aimed at strengthening existing regulations to prevent spills, including the Drilling Safety Rule, Workplace Safety Rule, and additional inspection and compliance efforts (U.S. Department of the Interior/BSEE, 2011). The Drilling Safety Rule implemented more rigorous standards for well design, casing and cementing practices, and blowout preventers. The Workplace Safety Rule requires companies to implement and maintain Safety and Environmental Management System (SEMS) programs. SEMS is a performance-based system for offshore drilling and production operations focusing on hazard analysis and mitigating risks. BSEE has also proposed a follow-on SEMS rule that further expands required training and requires third-party, independent audits of operators' SEMS programs. The Gulf of Mexico region has added 46 new inspectors with plans to add even more.[42] BSEE inspectors now witness far more activity on drilling rigs than before the *Deepwater Horizon* event, including critical tests of blowout preventers. Further reducing the likelihood of a well control incident developing into a catastrophic oil spill, BSEE now requires operators to have access to a well containment system before approving a drilling permit.

In addition to these regulatory and procedural reforms, government agencies and industry have expanded and refocused a number of research and development efforts aimed at improving technologies for spill prevention, containment and response, many that pre-date the *Deepwater Horizon* event:

- BSEE Technology Assessment and Research (TA&R) Program: The program has funded over 700 research projects since the 1970's related to oil, gas, and renewable energy development and is increasingly focused on safety issues associated with operations in the Arctic environment.[43] BSEE also operates the Ohmsett, the National Oil Spill Response Research and Renewable Energy Test Facility in Leonardo, New Jersey. This is the only facility where full-scale oil spill response equipment testing, research, and training can be conducted in a marine environment with oil under controlled environmental conditions (waves and oil types).[44]
- Department of Energy's Ultra-Deepwater (UDW) Research Program:[45] This is a joint government-industry R&D program run by the Department of Energy and originally focused generally on R&D related to deepwater oil and gas production. Since the *Deepwater Horizon* event the program has shifted its emphasis to assessing and mitigating risk associated with drilling operations. The Ultra-Deepwater Advisory Committee (UDAC), which advises DOE on the UDW Program, has also recommended research on human factors related to drilling safety.[46]

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42 As of May 2012. See: http://www.bsee.gov/uploadedFiles/BSEE/BSEE_Newsroom/Speeches/2012/Speech-OTC%20Breakfast%20Keynote-05-01-2012.pdf

43 See http://www.bsee.gov/Research-and-Training/Operational-Safety-and-Engineering.aspx

44 See http://www.bsee.gov/uploadedFiles/Fact%20Sheet-Ohmsett%20FINAL.pdf

45 The full title of the program is the Ultra Deepwater and Unconventional Natural Gas and Other Petroleum Resources Program. See http://www.fossil.energy.gov/programs/oilgas/ultra_and_unconventional/2011-2012_Committees/Draft_2012_Annual_Plan_1-10-12.pdf

46 See http://www.fossil.energy.gov/programs/oilgas/advisorycommittees/UDAC_2012_Report_-_Final_-_03-08-12_Revi.pdf

- Interagency Coordinating Committee on Oil Pollution Research (ICCOPR): The ICCOPR is a 14-member interagency committee established under the Oil Pollution Act of 1990. The purpose of the Interagency Committee is twofold: (1) to prepare a comprehensive, coordinated Federal oil pollution research and development plan; and (2) to promote cooperation with industry, universities, research institutions, State governments, and other nations through information sharing, coordinated planning, and joint funding of projects. Since the *Deepwater Horizon event*, the ICCOPR has focused on updating its research and technology plan to help align and inform the R&D efforts of its government member agencies.
- Ocean Energy Safety Advisory Committee (OESC): The OESC is a public federal advisory body of the nation's leading scientific, engineering, and technical experts. The group consists of 15 members from federal agencies, the offshore oil and gas industry, academia, and various research organizations. The Committee provides critical policy advice to Secretary of the Interior through the BSEE Director on improving all aspects of ocean energy safety.[47]
- The oil and gas industry has assembled four Joint Industry Task Forces (JITFs) of industry experts to identify best practices in offshore drilling operations and oil spill.[48] These task forces' outcomes and recommendations include:
    - **Procedures JITF**: This task force developed guidelines for the Well Construction Interface Document (WCID), which will address drilling contractor's Health, Safety, and Environmental (HSE) plans and the operator's SEMS and safety and risk management considerations on a well-by-well basis.
    - **Equipment JITF**: This task force reviewed current BOP equipment designs, testing protocols, and documentation. Their recommendations were designed to close any gaps or capture improvements in these areas. The JITF recommendations are being incorporated into an updated version of API RP 53 *Recommended Practices for Blowout Prevention Equipment Systems for Drilling Wells*, which is referenced in the BSEE drilling safety rule.
    - **Subsea Well Control and Containment JITF**: This task force developed recommendations for enhancing capabilities to capture and contain hydrocarbons quickly after a well blowout. This capability was achieved through the establishment of two collaborative containment companies – the Marine Well Containment Company (MWCC) and Helix Well Containment Group (HWCG). These two companies house the equipment and technology needed to quickly and effectively respond to loss of well control events.
    - **Oil Spill Preparedness and Response JITF**: This task force identifies potential opportunities for improving oil spill response.[49] The recommendations were subsequently addressed by the American Petroleum

47 See http://www.doi.gov/news/pressreleases/Ocean-Energy-Safety-Advisory-Committee-to-Hold-First-Meeting.cfm
48See http://www.api.org/oil-and-natural-gas-overview/exploration-and-production/offshore/api-joint-industry-task-force-reports.aspx.
49 See http://www.api.org/~/media/Files/Oil-and-Natural-Gas/Exploration/Offshore/OSPR-JITF-Project-Progress-Report-Final-113011.ashx

Institute (API) Oil Spill Preparedness and Response Subcommittee (OSPRS). The OSPRS developed an industry-funded, multi-year work program with projects in seven different work areas including: planning, dispersants, shoreline protection and cleanup, oil sensing and tracking, in-situ burning, mechanical recovery, and alternative technologies.

While catastrophic spill risks can never be completely eliminated, significant government and industry efforts continue to reduce the likelihood of an OCS catastrophic oil spill. Human error is usually at least a contributing factor in low probability/high consequence accidents, and the greater focus on human factors including the SEMS hazard analysis and the MWCC/HWCG rapid response containment systems should greatly reduce the likelihood that a loss of well control event will evolve into a catastrophic oil spill as discussed in this analysis.

Catastrophic Risks of the No Sale Options

Any analysis of the risks of OCS exploration and development must also be balanced with the increased risk of other catastrophic events in the absence of the Five Year Program. BOEM analysis of energy markets under of any of the No Sale Options indicate that there would only be a small decrease in overall energy demand as a result of the higher oil and gas prices in the absence of new OCS oil and gas development. The vast majority of foregone OCS production would be made-up by non-OCS oil and gas, or from other energy market substitutes such as coal, nuclear, or renewable energy sources. Most of these energy substitutes also entail some degree of catastrophic risk. It is difficult to quantify the extent catastrophic risks for producing energy substitutes would increase in the absence of OCS production, but the discussion below highlights the potential risks of these energy substitutes.

The most direct result of selecting the NSO would be increased production of domestic onshore oil and gas and increased foreign oil imports. While onshore oil production does not incur the risk of catastrophic well blowouts, the blowouts that could occur can still impose intense local damage. Further, substituting domestic oil with foreign oil effectively shifts most, but not all, of the oil spill risk from the United States to other countries. While many countries have extremely rigorous safety standards and regulatory regimes for oil and gas operations, other countries have significant gaps in addressing spill risk. In fact, devastating offshore oil spills have occurred worldwide. Notable examples include the 1979 IXTOC I well blowout that spilled a reported 10-30,000 barrels of oil per day into the Gulf of Mexico for nine months (NOAA’s Office of Response and Restoration); and the 1988 Piper Alpha platform fire in the North Sea that killed 167 personnel (Paté-Cornell, 1993). Similarly, increased imports of oil via tanker increase the risk of major spills nearer sensitive areas and population centers as tankers can carry several million barrels of oil at a time. Multiple hull tanker designs have dramatically reduced the risk of a tanker losing its entire cargo, but likely worst case discharge scenarios for tanker accidents are still in the range of several hundred thousand barrels of oil (Etkin, 2003), and tankers tend to have more accidents close to shore, where the impacts are much more severe.

Other types of catastrophic impacts can occur even with energy substitutes to OCS oil and gas. Severe impacts may happen throughout the energy chain leading from the extraction of raw materials to the production of fuels to the end-use of energy for heating, transportation, or power production. In some cases, as in offshore oil and gas extraction, catastrophic accidents can occur upstream in the energy chain. In other cases, there is potential for catastrophic accidents in downstream activities such as power production. Examples include:

- Nuclear Power: The high-profile disasters at Chernobyl and Fukashima highlight the risks of worst-case nuclear power plant accidents. Nuclear reactors also produce radioactive waste, creating the potential for environmental contamination and proliferation.
- Coal: Upstream mining involves the risk of mine accidents and severe environmental damage from acid runoff into groundwater. Downstream power generating activities produce fly ash, which must be contained and disposed of to avoid environmental contamination. In 2008, a fly ash storage pond breach in the Tennessee Valley Authority's (TVA's) Kingston, Tennessee, power plant resulted in the release of 5.4 million cubic yards of fly ash. Cleanup costs are estimated at $1.2 billion.[50]
- Hydropower: Dam failures can have severe localized consequences for nearby communities. According to the Federal Emergency Management Agency (FEMA) and Army Corps of Engineers, there are more than 80,000 dams in the United States (2,200 of which are used for hydropower).[51] Approximately one third of all U.S. dams pose a "high" or "significant" hazard to life and property if failure occurs (U.S. Department of Homeland Security, 2011).
- Wind and Solar Power: While not generally subject to large catastrophic accidents during use, wind turbines and solar cells may use specialty metals whose processing often involves the use of hazardous chemicals and may occur in countries with much less stringent environmental standards than in the U.S. Rare earth elements – used extensively in wind turbines – are often mined from deposits co-located with radioactive thorium. Production of these materials could lead to severe long term environmental impacts.

It is difficult to quantitatively compare risk and impact of one energy source over another, and calculate incremental increases in risk from energy substitutions. However, these examples reiterate the fact that energy production is never risk-free.

Detailed Cost Calculations

Notwithstanding the extenuating considerations discussed in the previous two sections, BOEM proceeded to undertake calculation of the potential environmental and social costs of a catastrophic oil spill. This section describes the methodology and assumptions used in making those estimates. Results are reported in 2012 dollars. As discussed, the many factors that determine the severity of a catastrophic oil spill's impact can lead to large ranges of possible costs. Due to the unpredictability in the many factors driving effects

50 See http://www.bloomberg.com/news/2011-11-03/coal-ash-disaster-lingers-in-tennessee-as-regulation-fight-rages.html.
51 See http://geo.usace.army.mil/pgis/f?p=397:5:0::NO.

from an unexpected future catastrophic OCS oil spill, the cost calculations are far less reliable than other measures developed for the Net Benefits analysis. In order to apply some cost value to a hypothetical catastrophic spill, BOEM estimates variations in cost measures based only on varying spill sizes. Other factors which influence cost, such as distance from shore, season of occurrence, and variability in ocean currents, are normalized at levels designed to produce a higher end of effects from a given spill size. Accordingly, the results estimated below represent a more severe outcome than can be expected to happen on average or at random.

Methodology

As described above, a catastrophic oil spill event is assumed to be characterized by the release of a large volume of oil over a long period of time from a well control incident. However, the volume and duration of the release are only two of the factors that will influence the nature and severity of the event's impacts. Other factors, that alone or more likely in combination can influence a catastrophic oil spill's impact, include but are not limited to human response, spill location, reservoir size and complexity, response and containment capabilities, meteorological conditions, and the type of oil spilled. Rather than account for each of these variables and adjust the impacts and costs accordingly, BOEM uses a benefit transfer approach based only on spill size with the major cost categories serving as a rough approximation of the largest foreseeable environmental and social costs of a catastrophic spill in each planning area. The spill sizes are consistent with the Programmatic EIS spill size assumptions summarized in OCS Catastrophic Event Spill Sizes. The benefits transfer approach is a method that applies values obtained from previous studies or historical data to a new situation where primary data has not been collected.

The economic cost of a catastrophic oil spill for this analysis is the value of the resources used or destroyed as a result of the spill. The economic cost of a spill may differ from the amount of compensation paid by responsible parties to those affected. Compensable damage is dependent upon particular legal statutes in place in the affected countries and may or may not include all aspects of the economic cost of a spill.

The report from Industrial Economics, Inc. titled *Inventory of Environmental and Social Resource Categories Along the U.S. Coast* (2012d) describes the challenges to estimating the costs for a potential catastrophic oil spill:

- When describing the potential impacts associated with a catastrophic event, it is important to distinguish between changes in economic *value* and changes in regional economic *activity*. Value, more specifically net economic value or consumer surplus, is measured by what individuals are *willing to pay* for something above and beyond what they are required to spend. This concept of value is recognized as the appropriate measure to compare the costs and benefits of policy alternatives and measure damages resulting from injury to natural resources.[52] Alternatively, economic activity reflects commercial revenues,

52See U.S. Environmental Protection Agency's *Guidelines for Preparing Economic Analyses* (2010) and U.S. Department of the Interior Natural Resource Damage Assessment Regulations (43 CFR Part 11).

employment, tax receipts, etc. and is generally driven by consumer expenditures. Large restitution or transfer payments are often more representative of the activity changes not the value changes associated with an oil spill.

- One of the most difficult economic costs of an oil spill to measure is the non-use value of the damaged ecosystem. Measuring the impact of a catastrophic spill event or tanker spill in monetary terms is increasingly dependent on the use of "equivalency analyses" such as habitat equivalency analysis or resource equivalency analysis. These techniques are replacing efforts to try to estimate social welfare values for natural resources for which there is no "market price," using stated preference surveys which estimate consumer surplus through the creation of hypothetical markets. In general, equivalency analyses determine the necessary scale of actions to restore the habitat and the time it would take to deliver a quantity of natural resource services equal to the reduction in ecosystem services over time. The magnitude of these equivalency costs can vary considerably based on the location, scale, and complexity of the resources.

Where market prices are non-existent it becomes necessary to assess the cost of damages using other, somewhat less direct methods. This analysis considers both the direct, market-based components of the economic cost (e.g., spill containment and clean-up, commercial fishing) and the non-market value of damages for resources not exchanged in markets (e.g., recreational activities, natural resources). Ideally, survey-based data would be collected for the non-market valuation. However, as in this analysis, when it is not feasible to undertake an original study to obtain the non-market values, the benefit transfer approach is used.

Potential Effects

In the broadest terms, as described in *Inventory of Environmental and Social Resource Categories* a catastrophic event in any of the program areas would have the potential for direct impacts on (1) physical and biological resources, and (2) the public's use and enjoyment of these physical and biological resources, as well as (3) direct and indirect impacts on regional economic activities, many of which are dependent upon healthy physical and biological resources and (4) clean-up and containment costs. Each of these four categories of impacts is described briefly below (Industrial Economics, Inc., 2012d). The Programmatic EIS (Department of the Interior/BOEM, 2012a) and *Inventory of Environmental and Social Resource Categories* (Industrial Economics, Inc., 2012d) provide a broad analysis of the impact categories that could be impacted from a catastrophic oil spill.

The discussion on physical and biological, public use, and economic activity resources below comes from the report *Inventory of Environmental and Social Resource Categories* (Industrial Economics, Inc., 2012d). This report contains information on the current level of resources and activities in each of the program areas.

Physical and Biological Resources

In all program areas, each phase of a catastrophic oil spill has the potential to result in adverse impacts to coastal or marine habitats and wildlife. The impact on physical and biological resources resulting from a spill of imported oil from a tanker would be largely the same as those resulting from a catastrophic oil spill from a well control incident. The exception would be that in the case of a tanker spill, the potential for acute and chronic effects on biological organisms in the water column is reduced, but not impacts on the ocean surface.

The impact on physical and biological resources in each of the program areas as a result of a catastrophic spill are shown below as natural resource damages (NRD).

Public Use of Resources

Coastal areas offer numerous opportunities for the public's use and enjoyment of coastal and marine resources. These include beach use, hunting, subsistence harvests, wildlife viewing, and other recreational activities, and recreational fishing. A catastrophic oil spill or tanker spill would result in a decrease in the number of trips taken by the public for the purpose of engaging in one or more of these activities, whether due to the imposition of use restrictions, or simply the public's perception of the quality and availability of natural amenities in the event's aftermath. If a catastrophic event or tanker spill were to occur during, or just prior to, the peak coastal use season (as assumed in these calculations), the number of foregone trips for public use or subsistence harvests would be particularly high.

The costs analyzed in this analysis for the potential effects on public use of resources are subsistence harvests and coastal recreation.

Economic Activity

Measures of changes in social welfare or consumer surplus are appropriate in the context of cost-benefit analyses and assessments of natural resource damages, but an alternative way of considering the impact of a catastrophic OCS or tanker oil spill is to assess its effect on regional economic activity in terms of jobs, labor income, and value added. In many, but not all coastal areas, regional economies tend to be dominated by tourism and recreation, commercial fishing, commercial shipping, and oil and gas production. Though not considered in detail here as this analysis attempts to study a national rather than regional approach, the national or regional economic context in which a catastrophic event occurs could have an effect on its impact. For example, during a recession or other period of low economic growth, workers who lose their jobs as a direct or indirect result of a catastrophic event may have greater than usual difficulty finding new employment, thereby increasing the severity of the economic effect (Industrial Economics, Inc., 2012d). On the other hand, some workers and/or owners in some businesses, such as commercial fishing, are likely to be hired to assist with containment/cleanup efforts or to house cleanup workers. Further information on the potential economic impacts can be found in *Inventory of Environmental and Social Resource Categories* (Industrial Economics, Inc., 2012d).

The economic activity costs included in this analysis are the lost profits from commercial fishing, life and non-fatal injuries, and the value of the oil and gas that is spilled, not the lost wages, etc. of factors of production that can find alternative employment.

Cleanup and Containment Costs

Clean-up and containment costs often represent the bulk of compensable damages resulting from marine oil spills. Clean-up costs can vary widely and are generally related to several factors including: the type of oil spilled, the physical characteristics of the spill location, water and weather conditions, the volume of spilled oil and the time (season). Economic resources dedicated to clean-up efforts represent losses to the economy, even if they often provide an injection of funds into the disrupted local economies, since they cannot be used in other constructive activities. Clean-up costs including labor, materials, and contracts are valued at their market prices in 2012 dollars for this analysis.

In addition to hired labor, volunteer, military, and government labor are often used in cleanup efforts around the world. These efforts represent an opportunity cost of clean-up because the individuals' efforts could have been used in other productive enterprises. Due to the presence of both volunteer and other non-wage labor and market distortions, the explicit financial cost and the true economic cost of clean-up activities may differ.

Cleanup costs used in this analysis may include some transfer payments. To the extent that clean-up cost estimates reflect real resources employed to conduct remediation activities, the cost component is a real social outlay. However, there may be payments to local communities or interests that are made for reasons other than the direct clean-up work. To the extent that our estimates reflect payments other than these real clean-up costs, they are transfer costs. Because of the uncertainty of the fund sources and payment types for cleanup and containment costs, this analysis considers all containment and cleanup costs in our cost estimate for a catastrophic spill.

A number of statutes, including the Clean Water Act (33 U.S.C. 1321(b)(7)), and the Outer Continental Shelf Lands Act (43 U.S.C. 1350) provide for fines against the parties responsible for an oil spill or for violations related to an oil spill. In the context of this analysis for a catastrophic spill, fines and other penalties not specifically for natural resource damages or other social and environmental costs incurred by society are considered "transfer payments." These transfer payments simply move funds from the responsible party to the government or other entity. Transfer payments do not involve real resource costs and are therefore excluded from this analysis.

The Gulf of Mexico Program Areas

Expanding upon the description of impacts presented in the previous section, this section details the specific Gulf of Mexico (GOM) resources and activities for which BOEM estimates environmental and social costs from a catastrophic event in the GOM program areas. For information on the resources that could potentially be damaged by a catastrophic oil spill, see *Inventory of Environmental and Social Resource Categories* (Industrial Economics, Inc., 2012d).

The social, environmental and oil spill clean-up cost factors in this analysis are generally estimated for the Central GOM, but are applied to catastrophic spill volumes in both the Eastern and Western GOM program areas. The only difference is that the Central and Western GOM program areas use values for both the shallow and deepwater while the Eastern GOM program area only uses the deepwater cost estimates.[53] While there are some differences in the coastal resources among planning areas, the many uncertainties in the factors that can determine spill severity (e.g., location, oil spill trajectory, time of year) a single GOM estimate serves the purpose of this analysis for a catastrophic spill.

Much of the analysis for potential GOM catastrophic spill costs is taken from the Regulatory Impact Analysis (RIA) for the Drilling Safety Rule published in 2010 (U.S. Department of the Interior/BOEMRE, 2010). The benefit-cost analysis for that rulemaking considered the environmental and social costs of a catastrophic spill event similar to the *Deepwater Horizon* event. Except for the spill containment and clean-up costs, the cost values for a catastrophic GOM oil spill are taken from this analysis.

The following sections will outline the different cost categories evaluated in the determination of a catastrophic oil spill cost in the GOM program areas.

Physical and Biological Resources

For information on the natural resources along the coast of the GOM, see *Inventory of Environmental and Social Resource Categories* (Industrial Economics., Inc., 2012d). The avoided costs for natural resource damages (NRD) depend on the particular circumstances associated with an oil spill. Natural resource damages from prior oil spills (excluding the *Deepwater Horizon* event) were used to inform this analysis.[54] Information on natural resource damage settlements was collected on coastal oil spills under the authority of the Oil Pollution Act. The values contained in the legal settlement documents represent the best source of available information on the monetary value of the natural resource damages associated with coastal oil spills. Settlement amounts reflect compromises based on factors other than the actual amount of damages, such as litigation risk with respect to legal issues in the case or the ability of parties to support protracted, complex litigation. Further, although this information is useful for the purpose of this analysis, it should not be relied on to determine the amount of natural resource damages associated with any particular oil spill, including the *Deepwater Horizon* event. Additional information on the spill dataset, assumptions, and other information on the GOM NRD settlements used in this analysis can be found in the Drilling Safety Rule RIA (U.S. Department of the Interior/BOEMRE, 2010).

Summary information on the seven previous small spills used for the benefit-transfer is reported in Table 20**.** The average damages across these spills were **$642 per barrel** in 2012 dollars, which BOEM uses as a conservative estimate for the cost calculations.

53 The Eastern GOM program area is the limited area being offered for leasing in the Five Year Program. The Eastern Planning Area encompasses the entire OCS administrative area offshore Florida.

54 *Deepwater Horizon* Natural Resource Damage Assessments have not yet been settled and thus are not included in this analysis.

Since the average costs used for this analysis are based on spills much smaller than a catastrophic spill, they may have poor predictive capability for the NRD costs of catastrophic spills. Similarly, a future catastrophic spill could result in a significantly higher natural resource damage value per barrel spilled, depending on the circumstances of the spill. For example, in the Exxon Valdez oil spill, which resulted in a release of approximately 262,000 barrels of oil, natural resource damages plus assessment costs averaged $5,405 per barrel in 2012 dollars, though in a much different climate and ecological context than the GOM.[55] Absent better data, the NRD assessment per barrel values estimated from seven previous GOM spills are used in each GOM program area, regardless of water depth.

Table 20: Seven Gulf Coast Spills: Natural Resource Damages[56,57]

Event	**Volume spilled (bbls)**	**NRD Assessment Costs $/bbl $2012**	**Injured Resources**
OCEAN 255/B-155/BALSA 37 Spill	8,619	1,367	366 birds, 2117 sea turtles, 5.5 acres mangroves, 255 acres seagrasses, 0.85 acres salt marshes, 0.22 acres oyster beds, 20 linear miles seawalls, surface waters, 1.34 acres bottom sediments and 39,827 cubic yards of oiled sands (13 linear miles)
Blake IV and Greenhill Petroleum Corp. Well 25	2,905	1,192	Intertidal marshes, marine and estuarine fish, bottom dwelling species, birds, sediments
Equinox Cockrell-Moran #176 well	1,500	947	1,221 acres saltmarshes, birds/wildlife, 12 acres mangroves, 21 acres subtidal sediments, recreational activities
Chevron BLDSU #5, West Bay Field	262	368	200 acres fresh water marsh vegetation, birds/wildlife
Ocean Energy/Devon Energy North Pass Storage Facility	300	451	120 acres freshwater marsh
Texaco Pipeline Company Lake Barre oil spill	6,548	116	4,237 acres of marshes, 7,465 finfish and shellfish, 333 birds,
M/VWestchester	13,095	52	Oiled shoreline and surface waters; lost recreational use of the Mississippi River.
Average per Event		**$642/bbl**	

The estimates of natural resource damages on a per barrel basis include several assumptions and caveats:

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55 The Exxon Valdez spill was a (non-OCS) case of a tanker spill close to shore and is probably more comparable to the risks that may be presented by activities in Cook Inlet or by tankering of imports in place of foregone OCS production. A discharge of the same amount of oil more than 100 miles from shore could have NRD costs much lower than $5,405 per barrel.

56 This estimate of natural resource damage per barrel is used as a proxy for catastrophic oil spills, but is not relevant in calculating damages for any particular oil spill, including the *Deepwater Horizon* event.

57 Department of the Interior/BOEMRE, 2010

- For this analysis, BOEM assumes that total damages for a given hypothetical event are a linear function of the amount spilled. While the costs associated with an oil spill are not directly proportional to the volume spilled (i.e. the cost per unit volume spilled is not constant), absent available data for catastrophic spills, BOEM assumes a linear relationship. The damages ultimately depend on the characteristics of an individual spill as noted earlier in the reference to the Exxon Valdez spill.
- The average damage value is not adjusted to account for distance to shore, evaporation, degradation, dispersion, containment, etc. It is assumed that reported natural resource damage values already incorporate these effects to the extent the incidents are comparable.
- The injured resources for the cases in the dataset are similar to the resources potentially damaged from a large GOM spill in the future.

Subsistence Use

Some communities and households in the GOM region depend on coastal natural resources for basic subsistence, but data on subsistence use is unrecorded and research is virtually nonexistent (Industrial Economics, Inc., 2012d). Based on the lack of data, valuing the subsistence use is extremely difficult (National Oceanic and Atmospheric Administration, 2006). Consequently, BOEM does not estimate lost subsistence use for the GOM program areas.

Coastal Recreation

Recreation activities are often affected when oil spills result in contamination of coastal or ocean resources. These damages can result in value losses to consumers who are either unable or choose not to participate in a given recreation activity due to the contamination or who do participate but have a lower quality experience than if there was no contamination. In order to arrive at a value of lost recreation, BOEM obtained the number of recreation trips (or days) lost and average value for each particular type of recreation trip.

In this section, benefit transfer is used to produce estimates of the value of lost recreation associated with a catastrophic oil spill event in the Gulf of Mexico for recreational fishing and beach recreation. Other recreational activities such as scuba diving, snorkeling and boating are likely to be affected as well, but estimates for those activities are not included in this analysis due to lack of information about the impacts and potential overlap among activities. In order to arrive at an estimate of the impact of a catastrophic oil spill, several assumptions are required about the size, duration, and location of the spill within the GOM program areas. In addition, this analysis does not account for the substitution of less desirable or more costly recreation sites for those that are affected by the spill.[58]

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58 Since this analysis is from a national perspective, if people chose not to go to beaches in the GOM and instead go elsewhere, they would still receive some consumer surplus from their trip. As a result, this analysis should net out the substitute consumer surplus. However, due to increasing complexities and the desire to develop costs from the upper end of a range, BOEM does not consider this substitute effect. As a result, the estimated consumer surplus losses are likely greater than they would be from a national perspective.

Recreation Fishing
Similar to other GOM estimates, recreational fishing social costs are taken from the RIA for the 2010 Drilling Safety Rule (U.S. Department of the Interior/BOEMRE, 2010). Benefit transfer was used to value the lost recreational fishing trips. Consumer surplus estimates (in dollars per activity day) were obtained from the same previous non-market valuation studies of recreational fishing used in the RIA (U.S. Department of the Interior/BOEMRE, 2010).[59]

All values in the seven studies were converted to current (2012) dollars, which resulted in an average value of $57.89 per day. This value was multiplied by the number of trips estimated to be lost from both State waters and the Federal exclusive economic zone (EEZ) to arrive at total estimated consumer surplus over the three-month period.[60] The total recreation value lost over the period is estimated to be **$118.8 million** in 2012 dollars.

Beach Recreation
The detailed analysis for valuing GOM beach recreation losses can also be found in the RIA for the Drilling Safety Rule (U.S. Department of the Interior/BOEMRE, 2010). Ideally, the number of recreation days lost would be calculated from beach surveys or flight surveys conducted during the affected period compared with data from the same time the previous year. In the absence of actual visitor counts, certain assumptions were made to estimate the recreation days lost. Using the *Deepwater Horizon* event as a data point, the percentage of oiled shoreline in each state as of July 22, 2010, was used to approximate the percentage of recreation days in each state that was affected. This calculation may underestimate lost beach days for much of the area because the total shoreline used to calculate the percentage of area affected includes areas that are not used for beach recreation.

Although most beaches along the Gulf Coast may remain open after a catastrophic oil spill, decreased visitation and a reduction in experience quality, ignoring possible offsetting gains from reduced crowding, for those that still participate in beach recreation are likely to occur. In this analysis, BOEM assumes that all beaches remain open, with a decrease in recreation days of 20% compared to historic levels. BOEM also assumes that remaining visitors experience a loss in consumer surplus due to decreased quality of the recreation activity. BOEM assumes a 20% loss in quality for each recreation day affected, following Chapman and Hanemann (2001).

Consumer surplus values for beach recreation per activity day were obtained from eight studies conducted in the Gulf Coast region.[61] The consumer surplus values averaged $94 per activity day. This value was then multiplied by the number of recreation days in each state to arrive at a total consumer surplus value for beach recreation during the three

59 See Table 17 on page 56 of the RIA (Department of the Interior/BOEMRE, 2010).
60 The number of trips lost is based on data from the *Deepwater Horizon* event. The lost fishing trips are estimated on page 53 of the RIA (Department of the Interior/BOEMRE, 2010).
61 These studies are shown on page 56 in Table 17 of the RIA (U.S. Department of the Interior/BOEMRE, 2012).

month period. Using these values, BOEM estimates a loss in the value of beach recreation of **$80.2 million** in 2012 dollars over the period. These estimates do not explicitly account for the availability of substitute beach sites, or the differences in behavior of local versus out of state visitors. As discussed earlier, if suitable substitutes are available, the decrease in consumer surplus would be smaller than the current assumption of no substitutes.

Commercial Fishing

For this analysis, commercial fishing is separated from recreational and "subsistence" fishing so that the appropriate cost calculations can be made for each group. For commercial fishing, BOEM analyzed the lost fishing profits[62] that would occur as a result of a catastrophic oil spill. One approach to calculating commercial fishing profits requires tallying revenue earned by industry operators, and subtracting operating costs. Operating costs include labor costs, such as wages for harvesting and processing; and non-labor costs such as fuel and supplies. For information on the commercial fishing industry in the GOM program areas, see *Inventory of Environmental and Social Resource Categories Along the U.S. Coast* (Industrial Economics, Inc., 2012d).

The Drilling Safety Rule RIA gathered available data on landings, commercial fishing revenues, and other factors (U.S. Department of the Interior/BOEMRE, 2010). Table 18 shows the data collected from the Drilling Safety Rule RIA on the profits and fishing closures following the *Deepwater Horizon* event. The "days of closure" column shows the effective days of closure of the entire commercial fishing area offshore Louisiana, Mississippi, and Alabama after the *Deepwater Horizon* event. Using the portion of the month that was closed to fishing, the commercial fishing profits were reduced by the percentage of days of effective closure in each month resulting in the lost profits in the final column. The table has been updated since the RIA was published with additional data for August, September, and October.

For this analysis, commercial fishing impacts are calculated based on the potential impact on commercial fishing profits, not because BOEM is estimating individual losses, but because lost commercial fishing profits are used as a proxy to represent welfare value lost to the nation as a result of a catastrophic spill. Welfare value is lost to the nation from smaller harvests, more resources expended for the same harvests, etc. To estimate the loss in profits, BOEM uses the estimated days of closure of fishing area.

62 Producers' profits are used as a proxy for producer surplus.

Table 18: Estimated Gulf State Profits Lost to Closures[63]

	Days of Closure	Days in Month	Commercial Fishing Profits (LA, MS, AL) millions (2009$)	Lost profits, millions (2009$)
May	3.9	31	$6.90	$0.90
June	10.9	30	$12.00	$4.40
July	8.9	31	$8.80	$2.20
August	6.3	31	$10.20	$2.09
September*	4.8	30	$10.20	$1.64
October*	2.3	31	$10.20	$0.77
		Total	**$58.30**	**$12.00**

*Due to lack of available data, August profits were used as an estimate of profits for September and October.

Based on the historical data from the *Deepwater Horizon* event, the lost profits to commercial fisheries due to a catastrophic oil spill in the GOM are estimated to be **$13.0 million** in 2012 dollars ($12.0 million in 2009 dollars).

Life and Nonfatal Injuries

As of 2010, two recorded deepwater blowout events resulted in injuries or fatalities. The first event, a 1984 blowout, resulted in four fatalities and three injuries and the second event, the 2010 *Deepwater Horizon* event resulted in eleven fatalities and seventeen injuries. For purposes of estimating costs from a catastrophic spill, BOEM averaged the life and nonfatal injuries in these two cases for the impact of a hypothetical catastrophic blowout. Remaining assumptions on the value of statistical life and nonfatal injures can be found in the RIA for the 2010 Drilling Safety Rule (U.S. Department of the Interior/BOEMRE, 2010).

For the purpose of calculating the impact of a catastrophic spill, each statistical life is valued at $8.5 million.[64] Based on the estimated value of eight deaths per incident, and the statistical value of a life at $8.5 million, the fatality impacts of a catastrophic well control incident are estimated to be *$68 million* in 2012 dollars.

Workers, on average, value non-fatal injuries on the job somewhere from $20,000 to $70,000 per expected job injury (Viscusi, 2005).[65] BOEM estimates an average value of job injuries as the mid-point of this range at $45,000 per injury. Assuming ten injuries

63 Data collected from the 2010 *Deepwater Horizon* event (U.S. Department of the Interior/BOEMRE, 2010). See *NOAA 2011* for closure data.
64 The $8.5 million value is the EPA value of statistical life of $7.4 million updated to current 2012 dollars. Although oil rig workers are involved in an inherently risky occupation, based on the lack of consensus in previous research focused on adjusting estimates of statistical life values for occupational risk, BOEM uses the EPA recommended figure for this analysis.
65 For example, a worker at the high end of this range would require $2,000 a year to face a one-in-25 chance of being injured that year (Viscusi, 2005).

expected per catastrophic oil spill, the value of non-fatal injuries as a result of a catastrophic spill is *$450,000* in 2012 dollars.

The combined value of fatal and nonfatal injures is estimated to be **$68.45 million** in 2012 dollars per catastrophic spill event.

Oil and Gas Production

BOEM is not estimating lost producer and consumer surplus for declines in the OCS oil and gas activity stemming from a catastrophic oil spill because such impacts are speculative. BOEM does, however, count the value of hydrocarbons lost in a well blowout and catastrophic spill at $100/bbl; an estimate that includes any lost natural gas.

Spill Containment and Clean-up

Spill and Containment costs are taken from the BP *Deepwater Horizon* event of 2010. In a January 31, 2012 fact sheet, BP estimated clean-up and containment costs to be $14 billion (BP 2012). Using a spill size for the *Deepwater Horizon* event of 4.9 million barrels this yields a clean-up and containment cost of **$2,857 per barrel** in 2012 dollars.

Cost Estimates for a Catastrophic Spill in the Gulf of Mexico

The environmental and social costs for Gulf of Mexico hypothetical catastrophic oil spills discussed above are summarized in Table 21.

Table 21: Conditional Environmental and Social Costs for a Catastrophic Oil Spill in the Gulf of Mexico

Cost Category (GOM)	$/bbl	GOM Shallow Catastrophic Spill (bbls)	GOM Shallow Catastrophic Spill (bbls)	GOM Deepwater Catastrophic Spill (bbls)	GOM Deepwater Catastrophic Spill (bbls)
		PER BARREL COSTS ($ millions)			
Estimated Spill Size (barrels)		**900,000**	**3,000,000**	**2,700,000**	**7,200,000**
Natural Resource Damages ($/bbl)	$642	$578	$1,926	$1,733	$4,622
Value of lost hydrocarbons ($/bbl)	$100	$90	$300	$270	$720
Spill Containment and Cleanup ($/bbl)	$2,857	$2,571	$8,571	$7,714	$20,571
		PER INCIDENT COSTS ($ millions)			
Recreation (Fishing and Tourism) Loses per incident		$199	$199	$199	$199
Commercial Fishing Profit Loses per incident		$13	$13	$13	$13
Value of Life and Nonfatal Injury loses per incident		$68	$68	$68	$68
		TOTAL SPILL COST ($ millions)			
TOTAL:		**$3,519**	**$11,077**	**$9,998**	**$26,194**
*Impacts not quantified include other health effects, commercial shipping, other impacts to the OCS oil and gas industry, property values, subsistence, and other consumer price impacts.					

Cook Inlet, Alaska

As the home to more than half the state's residents, the Cook Inlet area is a key economic center of Alaska (ECONorthwest, 2010). As discussed in *Inventory of Environmental and Social Resource Categories* (Industrial Economics, Inc., 2012d), a catastrophic oil spill in the Cook Inlet has the potential to damage wildlife and ecosystems and could have harmful effects on the area's recreation, commercial fishing, subsistence harvests, and tourism.

Physical and Biological Resources

For a discussion on the physical and biological resources available in the Cook Inlet, see *Inventory of Environmental and Social Resource Categories* (Industrial Economics, Inc., 2012d). The Exxon Valdez incident provides an estimate for the natural resources damages possible in the Cook Inlet. In the Exxon Valdez oil spill, which resulted in a release of approximately 262,000 barrels of oil, natural resource damages plus assessment costs averaged **$5,405 per barrel** in 2012 dollars.[66]

Subsistence Use

Estimates for Native Alaskan Cook Inlet area subsistence use are obtained from the OCS Study *Long-Term Consequences of the Exxon Valdez Oil Spill for Coastal Communities of Southcentral Alaska* (U.S. Department of the Interior/MMS, 2001). In the year after the Exxon Valdez spill, subsistence harvests declined from 9 percent to 77 percent in ten Alaska Native communities of Prince William Sound, lower Cook Inlet, and the Kodiak Island Borough. The primary reason for this decline was subsistence users' fears that oil contamination had rendered the resources unsafe to eat and later, fears that populations of subsistence resources had declined. While the decline in the value of subsistence harvests may be offset by compensation for employment in oil spill clean-up, that offsetting impact is not considered here.

BOEM estimates the subsistence losses of 50 percent of the harvest (taken from Table VII-1, U.S. Department of the Interior/MMS, 2001) in the year of the spill and 25 percent of the harvest (taken from Table VII-2, U.S. Department of the Interior/MMS, 2001) in the year following a spill in the Lower Cook Inlet area. The losses are approximately the subsistence harvest losses experienced for the Lower Cook Inlet area following the Exxon Valdez Spill. The population of Native Alaskans potentially impacted by subsistence harvest is about 4,100 individuals (Table V-5, U.S. Department of the Interior/MMS, 2001) which is also an estimate based on the impacts of the Exxon Valdez spill. The per capita harvest is estimated to be 300 pounds which is slightly below the village average harvest and above that of Native Alaskans living in towns (Table V-17, U.S. Department of the Interior/MMS, 2001). The value of subsistence use of $105 per kilogram is from the OECM documentation (Industrial Economics, Inc. et al., 2012a).

Table 22 summarizes the calculations for the estimated value of Native Alaskan lost subsistence harvests for a catastrophic oil spill in Cook Inlet.

Table 22: Estimated Cook Inlet Subsistence Loses

	Year of Spill	**Year After Spill**
Baseline Subsistence Harvest Per Capita (lbs)	300	300
Subsistence Loss (%)	-50%	-25%
Per capita harvest loss (lbs)	-150	-75
Estimated Pounds lost, (Based on 4,100 Native Alaskans in Southeast Alaska)	-615,000	-307,500
Kilograms (2.2 lbs/kg)	-279,545	-139,773
Value at $105/kg	**-$29,352,273**	**-$14,676,136**

66 See Appendix B: Natural Resource Damage Data (U.S. Department of the Interior/BOEMRE, 2010)

Summing the impacts of the year of the spill and the next year, the total value of lost Cook Inlet subsistence from a catastrophic oil spill is estimated to be about **$44 million.**

Coastal Recreation

Information on the types and impacts of tourism in the Cook Inlet region can be found in *Inventory of Environmental and Social Resource Categories Along the U.S. Coast* (Industrial Economics Inc., 2012d).

Recreational Fishing

Most of south-central Alaska's recreational activity is based in the Cook Inlet area (Industrial Economics Inc., 2012d). To calculate the potential recreational fishing losses due to a catastrophic spill, BOEM starts with the average number of trips taken in the area. The Alaska Sport Fishing Survey found that visits from 2006-2010 for Saltwater Fishing in the Cook Inlet averaged 389 trips per day (number of angler-days).[67] BOEM then multiplied the number of trips by the duration of the spill (using the upper end of the range, 80 days). BOEM assumes that all of the trips during the spill period are lost because, unlike in the GOM, it is unlikely that any portion of the Cook Inlet would be untouched by oil in the event of a catastrophic spill. The assumption that 100 percent of the fishing will be lost is likely an upper estimate but is used to capture some of the subsistence value residents other than Native Alaskans in South-Central Alaska may lose.

A 2003 study estimates that the consumer surplus values for recreational fishing in the Cook Inlet had an average value of $139.75 (in 2012 dollars) after weighting for local, Alaska, and non-resident fisherman. Consumer surplus value per fishing day was taken from the literature (Criddle et al., 2003). The number of fishing trips lost multiplied by the value of a fishing trip results in the total value of fishing trips lost. For the purposes of estimating a the value of losses from recreational fishing, BOEM calculates a 100 percent loss over an 80 day spill to total **$4.35 million** (in 2012 dollars).

Wildlife and Whale Watching

In summer 2011, over one million people visited southeast Alaska and about 884,000 visited south central Alaska. These figures clearly reflect the fact that individuals are visiting more than one region during their trips. Of the total summer visitors, 52% indicated they engaged in wildlife watching (McDowell Group, 2011)

Some wildlife watching activities in south central Alaska would likely be adversely affected by an oil spill. For the purpose of developing an estimate of the value of the potential wildlife viewing recreation losses that might be associated with a large oil spill, the focus is on visits to south central Alaska.

The average number of visits to south central Alaska from 2006-2011 was 912,411 (McDowell Group 2011). Based on other data from the Fish and Wildlife Survey data, 52% (474,454 visitors) view wildlife and have a value of $118.65 per day (U.S.

67 Ideally BOEM would want monthly data in order to estimate losses for a particular time of year. However, only annual data is available, so the annual value is divided by 365 to get the trips per day value.

Department of the Interior/FWS, 2006). BOEM assumes the worst case duration scenario that the spill occurs in the summer and lasts for 80 days (53% of the summer season). Assuming half the value is lost from a catastrophic spill in the summer season lasting 80 days, the total value is approximately **$15 million** in 2012 dollars.[68]

Commercial Fishing

As discussed in *Inventory of Environmental and Social Resource Categories* (Industrial Economics, Inc., 2012d), a catastrophic oil spill in the waters of Cook Inlet could significantly damage the area's commercial fishing industry. The report goes on to state that, "within the Cook Inlet, salmon (particularly sockeye salmon) accounts for most of the economic value derived by the fishing industry." In 2008, the industry harvested approximately 21 million pounds of salmon with a value of $22.3 million (Resource Development Council for Alaska, Inc., 2010). Because the Cook Inlet is unlike the fishing areas in the Gulf of Mexico in that there are less likely to be fishing areas not contaminated by oil in the event of a catastrophic spill, this analysis estimates the full single year value of Cook Inlet Salmon Fishing output of **$22.3 million** would be lost as the result of a catastrophic spill.

More information on the impact of commercial fishing and seafood processing in the Cook Inlet can be found in *Inventory of Environmental and Social Resource Categories Along the U.S. Coast* (Industrial Economics, Inc., 2012d).

Spill Containment and Clean-up

Spill and Containment costs are taken from the 1989 Exxon Valdez spill and adjusted to 2012 dollars. The Exxon Valdez spill was approximately 262,000 bbls and resulted in clean-up costs of $2.1 billion (in 1991 dollars).[69] Converted to 2012 dollars, this total results in clean-up costs of $3.57 billion or **$13,635 per barrel**.

Cost Estimates for a Catastrophic Spill in the Cook Inlet

The values for a catastrophic spill in the Cook Inlet program area are summarized in the Table 23.

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68 Note that the actual impact can vary greatly from the estimated number as all spills may not occur in the summer, no adjustment has been made for partial day visits, all wildlife watching trips may not be in areas impacted by a spill, whale watching is not monetized separately, and the visits of residents are not included.
69 See Exxon Shipping Co. et al. v. BAKER et al.
http://caselaw.lp.findlaw.com/scripts/getcase.pl?court=US&vol=000&invol=07-219
Calculation: ($2,902,410,000/262,000bbls)

Table 23: Conditional Environmental and Social Costs for a Catastrophic Oil Spill in the Cook Inlet

Cost Category (Cook)	$/bbl	Low Catastrophic Spill (bbls)	High Catastrophic Spill (bbls)
		PER BARREL COSTS ($ millions)	
Estimated Spill Size (barrels)		**75,000**	**125,000**
Natural Resource Damages ($/bbl)	**$5,405**	$405	$676
Value of lost hydrocarbons ($/bbl)[70]	**$100**	$8	$13
Spill Containment, Cleanup and Damage Assessment ($/bbl)	**$13,635**	$1,023	$1,704
		PER INCIDENT ($ millions)	
Native Alaskan Subsistence Harvests		$44	$44
Recreation (Fishing and Tourism) Loses per incident		$20	$20
Commercial Fishing Profit Loses per incident		$22	$22
Value of Life and Nonfatal Injury loses per incident[71]		$68	$68
		TOTAL SPILL COSTS ($ millions)	
TOTAL ($Millions):		**$1,589**	**$2,546**
*Impacts not quantified include other health effects, commercial shipping, other impacts to the OCS oil and gas industry, property values, subsistence, and other consumer price impacts.			

The Chukchi and Beaufort Seas, Alaska

Physical and Biological Resources

As described in *Inventory of Environmental and Social Resource Categories,* the Arctic Ocean of Alaska's North Slope is unique among U.S. coastal waters. Ice formation typically begins in October, and does not begin to break up until April or May. The ecological food web in the Arctic consists of primary producers and other microorganisms, benthic invertebrates, fish, marine mammals, and birds. Primary producers rely on sunlight, making seasonal differences critically important to the functioning of Arctic ecosystems (Industrial Economics, Inc., 2012d).

Given the limited information available to estimate the vast range of potential social and environmental costs from a catastrophic spill in the Arctic, BOEM is using a "benefit-transfer" technique.[72]

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70 The same hydrocarbon loss value from the GOM is used for the Cook Inlet.
71 Taken from the life and nonfatal injury values for the GOM.
72 Benefit transfer takes the estimated costs from previous studies and transfers them to the current context. In situations where time or resources do not permit extensive data collection or primary research, benefit-transfer may be an appropriate technique for evaluating the magnitude of economic costs of a hypothetical event. There are many caveats that accompany use of this approach, the most important perhaps being the

To estimate the natural resource damages for the Beaufort and Chukchi program areas, BOEM doubles the dollar per barrel factor used for the GOM. The unique nature of Arctic resources do not allow for a benefit transfer from the Cook Inlet. While doubling of the GOM values may appear arbitrary, BOEM believes that damages from a catastrophic oil spill likely are somewhere in-between the Cook Inlet and the GOM per-barrel damages, so doubling the GOM values may overstate the damages in the Arctic, although the costs for any particular spill will vary widely. The doubling the $642 per barrel natural resource damage cost for the Arctic results in a figure that is close to the two highest dollar per barrel spills in Table 20. Labor, materials, and transportation drive cleanup costs and each of these will be significantly more expensive in the Arctic.

Since no natural resource damage estimates are available for a possible catastrophic oil spill in each of the Artic planning areas BOEM extrapolates using existing estimates. The GOM planning areas use the NRD settlements from seven historical spills all much smaller than a catastrophic spill. For the Arctic, the sensitivity is lower compared to the biota in the Gulf of Mexico, but the resiliency and recovery is also expected to be lower.[73] The Chukchi and Beaufort planning areas are considered less sensitive to the impact of a catastrophic oil spill due a lower population of plant and animal life. Offsetting that lower sensitivity is the fact that it is likely less resilient due to the longer life cycles and generational recovery time for plants and animals. The generational cycle in the Arctic for many animals may be several years, while the generational cycle in the GOM may be closer to seasons or a year.

Alaska costs as double GOM costs is a relationship used in some other BOEM analyses to estimate oil and gas exploration and development costs in the Arctic. Thus, absent other NRD data, this relationship also is judged appropriate for applying to natural resource damage costs. The $642 per barrel costs for natural resource damages in the GOM are being doubled to **$1,284/bbl** in 2012 dollars for both the Chukchi and Beaufort program areas.

Subsistence Use

Most of the population and activity near the Arctic program areas occurs in small subsistence communities (Industrial Economics, Inc., 2012d). The harsh climate and the difficulty of physically accessing the North Slope limit recreational public use in the Arctic (Industrial Economics, Inc., 2012d). For more information on the communities using subsistence harvests in the Arctic, see *Inventory of Environmental and Social Resource Categories* (Industrial Economics, Inc., 2012d).

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extent to which the baseline site or situation from which the values are to be transferred is similar to those in the current study to which those values will be applied.

73 The scaling for the Arctic planning areas generally considers both sensitively and resilience, but due to lack of data, is just estimated. The term "sensitivity" is the vulnerability of the planning area to the impacts of a catastrophic oil spill. Resilience is comprised of two elements: the planning area's ecosystems ability to resist change, and ability to recover from significant stress (catastrophic oil spill) that has occurred. While analytical results of sensitivity and resiliency differ, considered together they provide a more comprehensive understanding of how and why program areas could be considered "sensitive" in the context of estimating NRD.

For a catastrophic oil spill, it is assumed that two entire years of Arctic marine mammal subsistence harvests and one and one-half years of Bowhead whale harvests would be lost. Based upon a historical average of the estimated kilograms of bowhead and marine mammal subsistence harvested, BOEM assigns a loss value of **$20.85 million** in the Beaufort and **$68.57 million** in the Chukchi program areas regardless of the size of the spill. BOEM recognizes that no monetary value can be placed on the cultural value of subsistence harvests to Native Alaskans, but as a proxy for this cultural value, BOEM uses these estimated monetary values. The values and calculations are summarized in Table 24.

Table 24: Arctic Harvest Subsistence Values

	Average Whales	Estimated Kilos Harvested	Value of Annual Bowhead Harvest ($105.00/kg)	Ratio Marine Mammals to Bowhead Whales	Estimated Marine Mammals Harvest (kilos)	Estimated Value of Other Marine Mammals $105.00/kg	Estimated Value of Fall BW & Annual MM Harvest for Year of Spill ($105.00/kg)	Estimated Value of All Bowhead Whale & Marine Mammal Harvest for Year Following Spill ($105.00/kg)
Fall Beaufort Harvest:	3.2	36,794	$3,863,388				$3,863,388	$3,863,388
Spring Beaufort Harvest:	8.9	102,694	$10,782,890					$10,782,890
Beaufort Marine Mammals				0.080	11,147	$1,170,414	$1,170,414	$1,170,414
Total Beaufort:		139,488					$5,033,803	$15,816,692
Total Estimated Beaufort Subsistence Loses (1.5 yrs.)								**$20,850,495**
Fall Chukchi Harvest:	7.4	85,670	$8,995,352				$8,995,352	$8,995,352
Spring Chukchi Harvest:	8.9	102,694	$10,782,890					$10,782,890
Chukchi Marine Mammals				1.006	189,527	$19,900,329	$19,900,329	$19,900,329
Total Chukchi:		188,364					$28,895,681	$39,678,571
Total Estimated Chukchi Subsistence Loses (1.5 yrs.)								**$68,574,252**

Assumptions:

- The fall bowhead whale hunt and marine mammal harvest are impacted in the year of the catastrophic spill. Both the spring and fall harvests are forgone in the year following a catastrophic spill.

-The value of the subsistence harvests is $105 per kilogram value which is from BOEM's OECM model (Industrial Economics, Inc. et al., 2012a). BOEM recognizes that no monetary value can be placed on the cultural value of subsistence harvests by Native Alaskans.

- Beaufort includes the Native villages of Nuiqsut and Kaktovik, Chukchi includes Barrow, Wainwright, and Pt. Hope.

- Values/rates/ratios taken from January 2008 NOAA FEIS for Issuing Annual Quotas to the Alaska Eskimo Whaling Commission (NOAA, 2008) and the NOAA database on Bowhead whale harvests[74].

-Assume 25,372 pounds per whale harvested (NOAA 2008, Table 3.5-2)

-Average Kilograms per whale 11,533

-Unlike some of the other values which are converted to a dollar per barrel metric, the same seasonal loss is used for both low and high volume catastrophic spill event sizes.

74 See http://www.fakr.noaa.gov/protectedresources/whales/bowhead/eis0108/EISBowheadSections.pdf

Commercial Fishing

Based on climate change concerns, as of 2009, the United States government has banned commercial fishing in U.S. waters north of the Bering Strait, so no estimates of commercial fishing values are being made for the Arctic. More information on commercial fishing in the Arctic can be found in *Inventory of Environmental and Social Resource Categories.*

Spill Containment and Clean-up

Rates of oil biodegradation in the Arctic are expected to be lower than temperate environments such as the GOM. While a significant number of vessels are contracted in case of contingency, and clean-up equipment is prepositioned, in the case of a catastrophic spill, significant resources would still need to be moved from other parts of Alaska and the lower 48 states. Sea ice coverage may assist in some oil-spill response techniques, such as in-situ burning and chemical dispersant application, but the results of these techniques are unknown.

Because of the higher costs in the Arctic oil spill response, clean-up, and containment costs are also being doubled from the GOM program areas. Doubling the GOM value of $2,857 per barrel from Table 21 yields a clean-up and containment cost of **$5,714 per barrel** in 2012 dollars.

Cost Estimates for a Catastrophic Spill in the Chukchi and Beaufort

The values for a catastrophic spill in the Arctic area are summarized in the Table 25.

Table 25: Conditional Environmental and Social Costs for a Catastrophic Oil Spill in the Arctic

Cost Category (Arctic)	Dollar per Barrel Cost	Beaufort Catastrophic Spill (bbls)	Beaufort Catastrophic Spill (bbls)	Chukchi Catastrophic Spill (bbls)	Chukchi Catastrophic Spill (bbls)
		PER BARREL COSTS ($ millions)			
Estimated Spill Size (barrels)		**1,700,000**	**3,900,000**	**1,400,000**	**2,200,000**
Natural Resource Damages ($/bbl)	$1,284	$2,183	$5,008	$1,798	$2,825
Value of lost hydrocarbons ($/bbl)[75]	$100	$170	$390	$140	$220
Spill Containment, Cleanup and ($/bbl)	$5,714	$9,714	$22,286	$8,000	$12,571
		PER INCIDENT COSTS ($ millions)			
Value of Life and Nonfatal Injury loses per incident ($million)[76]		$68	$68	$68	$68
Subsistence Harvests ($million)		$21	$21	$69	$69
		TOTAL SPILL COSTS ($ million)			
	TOTAL $Millions:	**$12,156**	**$27,772**	**$10,074**	**$15,753**
*Impacts not quantified include other health effects, commercial shipping, other impacts to the OCS oil and gas industry, property values, recreational and commercial fishing, and other consumer price impacts.					

Estimated Cost of a Catastrophic Tanker Oil Spill

As mentioned in the section titled Catastrophic Risks of the No Sale Options, BOEM assumes a catastrophic event could involve an ultra large crude carrier (ULCC) tanker of 550,000 deadweight tonnage and a maximum cargo of 3.52 million barrels grounding within 50 miles of shore and releasing up to 1.76 million barrels of its cargo. ULCCs offload at the Louisiana Offshore Oil Port (LOOP) and it would be highly unlikely that the spill would occur closer than 50 miles to shore. The largest event in the near shore GOM would likely be a spill from an Aframax tanker headed towards the Houston Ship Channel after lightering in the Western or Central GOM. The maximum spill volume in that case would most likely be 384,000 barrels. Therefore the cost estimates for a catastrophic tanker oil spill are applied to an oil spill of 384,000 barrels for the low case and 1.76 million barrels for the high case and are summarized in Table 26.

75 The same hydrocarbon loss value from the GOM is used for the Arctic.
76 Taken from the life and nonfatal injury values for the GOM.

Table 26: Conditional Environmental and Social Costs for a Catastrophic Tanker Oil Spill Offshore in the GOM

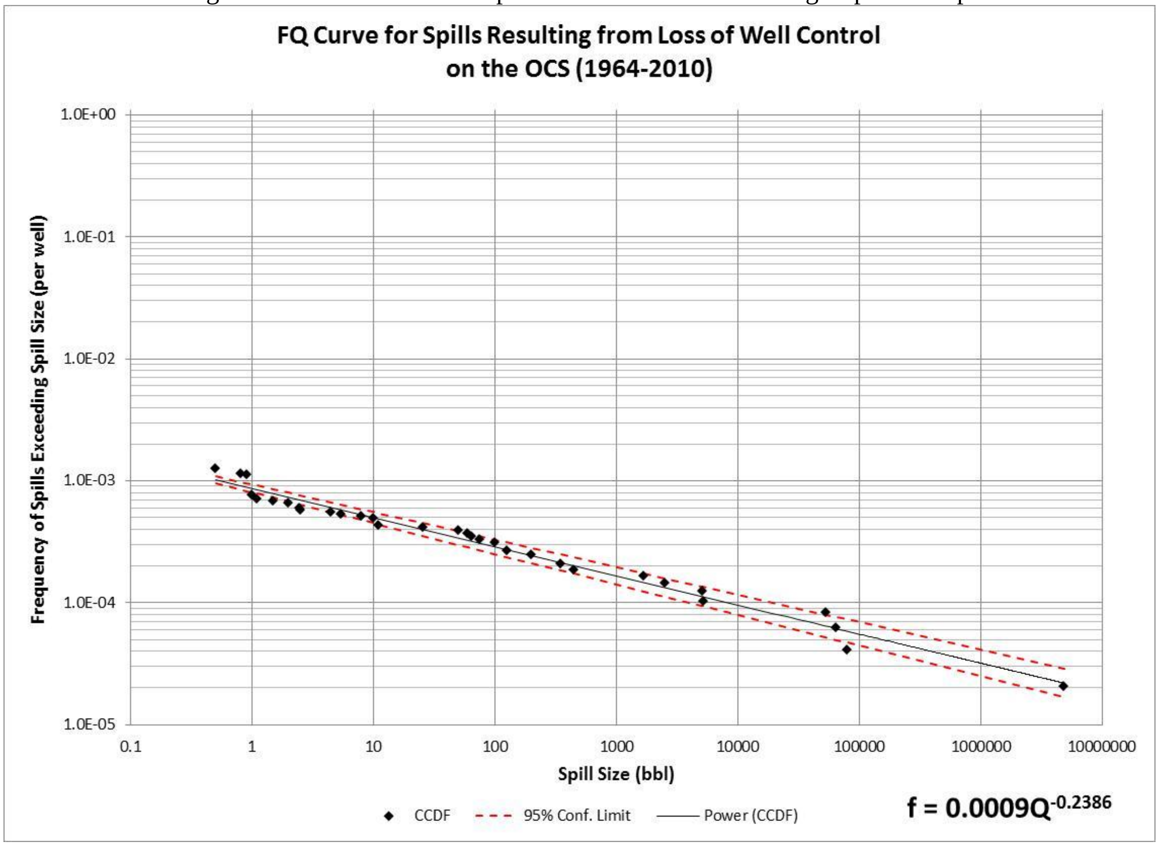
Cost Category (Tankers)	Dollar Per Barrel Costs	Tanker Catastrophic Spill (bbls)	Tanker Catastrophic Spill (bbls)
		PER BARREL COSTS ($ millions)	
Estimated Spill Size (barrels)		**384,000**	**1,760,000**
Natural Resource Damages ($/bbl)	$642	$247	$1,130
Value of lost oil ($/bbl)[77]	$100	$38	$176
Spill Containment, Cleanup and Damage Assessment ($/bbl)	$2,857	$1,097	$5,029
		PER INCIDENT COSTS ($ millions)	
Recreation (Fishing and Tourism) Loses per incident ($million)		$199	$199
Commercial Fishing Profit Loses per incident ($million)		$13	$13
		TOTAL SPILL COSTS ($ millions)	
TOTAL ($Millions):		**$1,594**	**$6,546**
*Impacts not quantified include other health effects, commercial shipping, other impacts to the OCS oil and gas industry, property values, subsistence, and other consumer price impacts.			

Detailed Frequency Calculations

To make estimates regarding the risked cost of a catastrophic oil spill, an estimate of probability of an event occurring was necessary. However, given a lack of relevant catastrophic oil spill historical data points, any specific spill probability would be questionable. As a rough approximation, the frequency of loss of well control and the resulting size of oil spill was calculated. Figure 5 below shows the frequency of loss of well control experienced per well drilled with an oil spill exceeding a specified size. The equation from this calculation allowed BOEM to use the spill sizes defined in Table 11 to determine the frequency of loss of well control with a spill of low (or high) catastrophic spill volume. After Figure 5, BOEM lists thirteen points from the Programmatic EIS which describe how the frequency calculations were made (U.S. Department of the Interior/BOEM, 2012a).

77 The same hydrocarbon loss value from the Gulf of Mexico is used for the oil lost in tanker spills.

Figure 5: Estimated Frequency of OCS Crude and Condensate Spills
Resulting from loss of well control per well drilled and exceeding a specified spill size



1. Figure 5 shows the frequency of loss of well control (LWC) per well exponentially decreases as spill size increases. See note 9 for more detail.
2. The BSEE database on LWC includes incidents from 1956 to the present day. Most records in the BSEE database can be viewed at http://www.bsee.gov/Inspection-and-Enforcement/Accidents-and-Incidents/Listing-and-Status-of-Accident-Investigations.aspx. The BSEE database also contains a few additional observations besides those available online. As can be expected, the quality of information improves as a function of time. Only the period 1964-2010 is considered herein because of adequate quality of the information. BOEM undertook a substantial effort to quality control data, when possible identifying and confirming for each incident the relevant API well number, bottom OCS lease number, platform and/or rig, etc. This allowed BOEM to check the timing of a particular LWC incident relative to well operations documented in shared BSEE/BOEM information management systems. BOEM successfully validated more than 90% of all records to well type and operational phase in advance of completing this analysis.
3. The sample size of OCS LWC incidents is small, even when including all OCS Regions. No LWC incidents have occurred or have been reported in the Alaska or Atlantic OCS Regions. To obtain a sufficiently large sample size to estimate both historical frequency of LWC and the relative frequency of different sized oil spills (resulting from LWC), 283 incidents between 1964 and 2010 are considered. LWC incidents occurred during exploration drilling/coring (75/2), development

drilling/coring (82/1), completion (21), workover (55), production and shut-in (37; a number during hurricanes), and temporary and permanent abandonment (10) operations. Most historical LWC incidents resulted in the surface release or diversion of natural gas; in fact, the database only includes 61 instances of crude or condensate surface releases since 1964. Moreover, the typical crude or condensate spill size is relatively small; the median spill size, including the DWH event, between 1964 and 2010 was 2 bbl.

4. The MMS changed the definition of and reporting requirements for LWC in 2006; prior to that, there was a reporting requirement for blowouts. This resulted in a detectable difference in LWC frequency after 2006 (see trend discussion below in note 7). It is possible that certain incidents that occurred before 2006 were not historically considered LWC incidents that would be considered such following the 2006 change. The BSEE database also contains records for the Gulf of Mexico OCS that SINTEF's worldwide blowout and well release database does not and vice versa. For example, there is a difference of twelve records in the 1983-2007 period. These differences can be attributed in part to the fact that BSEE and SINTEF use overlapping, but different definitions of LWC.
5. This analysis essentially assumes that wells spudded or drilled is an unbiased exposure variable (in aggregate) to estimate the frequency of LWC from all OCS operations. It is relatively simple to understand and collate and can be readily compared to BOEM's scenario of OCS exploration and development for the Five Year Program. However, BOEM recognizes that number of wells spudded or drilled likely underestimates all exposure over the varied exploration, development, and production operations during which LWC may occur. While the number of wells spudded or drilled works well for drilling-related incidents, the number of well completions, number of well workovers, number of active producing wells or well producing years, and number of temporary and permanent abandonment operations are expected to be comparatively better exposure variables for LWC incidents occurring during those operations. Not including that additional exposure (either in terms of an activity level or time exposure) results in a relatively conservative treatment of frequency estimation. For example, more than 42,000 downhole intervals were completed on wells in the Gulf of Mexico OCS alone during the 1964-2010 time frame, not accounting for injection intervals. Completion may involve a distinct re-entry into the borehole. While BOEM/BSEE has compiled the data for most of these other exposure variables for the historical period (1964-2010), the spill size data for such operational categories cannot be statistically analyzed (using this methodology) due to the small number of crude/condensate spills from LWC in each category.
6. The exposure variable, OCS wells spudded or drilled, includes original boreholes, sidetrack boreholes, and bypass boreholes for both exploration and development wells. No boreholes associated with both surface and bottom state leases are included in the exposure data. Similarly, no relief, stratigraphic test, COST, or other wells are included in exposure data. Approximately 48,450 exploration and development boreholes were spudded or drilled in the Alaska, Atlantic, Pacific, and Gulf of Mexico OCS Regions from 1964 through 2010 (36% exploration / 64% development). Many wells in the Pacific and Gulf of Mexico OCS actually have

numerous boreholes, especially when including bypasses and sidetracks. Approximately 25% of boreholes in the Gulf of Mexico and Pacific OCS Regions are bypasses and/or sidetracks. Note that less than 5,000 boreholes have been spudded or drilled in water depths greater than 200 m in the Gulf of Mexico and Pacific OCS Regions. Injection wells are included in the count of development boreholes. In the Gulf of Mexico OCS, boreholes originally spudded as exploration boreholes are often later completed and eventually produced. In this analysis, if LWC occurred during completion, workover or production operations, such incidents were considered development related.

7. There is no statistically significant trend in the frequency of LWC or LWC with spills (when standardized by wells spudded per year) except after the LWC rule changes introduced in 2006. Incident reporting associated with non-drilling operations increased by a factor of ~2 compared to the historical reporting rate. This suggests that it is likely that equivalent events were unreported prior to 2006. Because of the overall lack of definitive trend, the period from 1964 through 2010 was used in aggregate, despite rather substantial changes in regulation, technology, and industry operations/practices. This allows for the inclusion of some relatively large (≥ 1,000 bbl) oil spills before 1971 when major regulations changes were introduced; otherwise, after 1971, the spill next largest to the DWH event is 450 bbl.
8. LWC frequencies can be standardized by operational phase and well type as is available for the SINTEF database (see DNV, 2011a). The LWC frequency across exploration, development, and production operations is not the same and treating them in aggregate introduces some error/uncertainty because of the lack of treatment of specific exposure. In aggregate, the OCS LWC frequency is 0.006 incidents per well spudded or drilled when accounting for all LWC incidents regardless of operational phase and oil spill occurrence. The OCS LWC frequency for exploration drilling is 0.0044 incidents per well spudded or drilled, whereas the OCS LWC frequency for development drilling is 0.0027 incidents per well spudded or drilled. While it has been suggested that there is greater incidence of kick (a precursor to LWC) in deepwater (defined here as >200 m) (see note 11 below), the frequency for LWC in deepwater is less than shallow water. Of the 283 OCS LWC incidents considered, 21 instances of LWC occurred in >200 m (13 LWC incidents from drilling; 7 of these 13 incidents were exploratory). In fact, only 5 crude/condensate spills (2 during exploration drilling; 2 during exploration well abandonment; 1 during a development well workover) have resulted from LWC incidents in > 200 m. Over the same time period, the total vertical depth and average water depth of boreholes notably increased, especially since the early 1990s as industry moved into relatively deeper water and/or targeted relatively deep gas plays on the shallow Gulf of Mexico shelf. That trend is coincident with a decrease in the number of boreholes being spudded and drilled per year. Similarly, the number of boreholes relative to each well also increased over the time period considered. Despite these notable trends, the actual frequency of LWC in deepwater is less than in shallow water. Although frequency of LWC for wells characterized by HP/HT downhole conditions was not calculated, it is expected to show a comparatively greater incidence (DNV, 2011a).
9. The power law fitting ($f = \alpha Q^{\beta}$) follows the methodology presented in DNV (2011b). In this equation, f corresponds to the frequency of crude/condensate spills per well

exceeding spill size *Q* (bbl). Alpha (α) describes the relative frequency of spill occurrence, whereas beta (β) defines the power relation between spill size and frequency. For scaling purposes, alpha can be compared to the frequency for all LWC discussed above in note 8. The complementary cumulative density function (CCDF), or sample complementary cumulative frequency distribution, shows the number of spill events per exposure that are greater than or equal to a given spill size. The cumulative density function (CDF) is first estimated by ranking the OCS LWC spill observations by size and counting the observations equal to or less than that spill size. The CCDF essentially reverses the observation count for the CDF. The uncertainty in both the CDF and CCDF must be acknowledged given the limited sample size and relatively few observations in the extreme value tail. In fact, there are no observations between 80,000 bbl and 4,900,000 bbl, and approximately 96% of the cumulative spill volume following LWC is accounted for in a single incident (i.e., DWH event). The power law is fitted to the CCDF using least squares regression. The fit is statistically significant at the 99% level ($r^2 = 0.98$). Confidence intervals at the 95% level were calculated and are displayed above.

10. The power law parameters and confidence limits only offer an approximation of the exceedance frequency of spill sizes related to LWC. The distribution of spill sizes resulting from LWC (n=61) could not be definitively shown to follow a power law distribution, so estimates using least squares regression of the power law parameters may be biased (see Clauset et al., 2009). Dozens of other non-normal, extreme value probability distributions (e.g., log normal, exponential, general extreme value, etc.) were also tested against data observations using maximum likelihood estimators, and no distribution could confidently be fitted to the limited LWC spill data observations.
11. Using this method, there is insufficient LWC spill occurrence data to confidently differentiate by well type or operational phase, water depth, downhole parameters, etc., although these variables may contribute to well complexity and LWC risk. For example, Pritchard and Lacy (2011) report that wellbore instability (kick/loss of circulation) occurs as much as 10% of total deepwater time, and, moreover, that kick incidence (fluid influx from formation into the wellbore) is greater in deepwater wells than other “normal” wells. Holand and Skalle (2001) also suggested an increased kick frequency with borehole depth and water depth. The Mechanical Risk Index (MRI) has been suggested as a complementary analytical tool to better characterize well complexity and well control risk, as well as evaluate non-productive time and drilling cost (Pritchard and Lacy, 2011; Skogdalen and Vinnem, 2012). The MRI, described in detail in Kaiser (2007), accounts for the following principal factors: total measured depth, vertical depth, horizontal displacement, water depth, number of casing strings, and mud weight at total depth. The Macondo well has been classified as a particularly complex well according to the MRI criteria. It is important to note that drilling complexity and difficulty does not necessarily equate to frequency of LWC, despite the apparent relationship between kick frequency and certain borehole parameters (Holand and Skalle, 2001). Although certain parameters may contribute to additional risk, the OCS data suggests primary and redundant secondary barriers, newer technology, and better trained personnel (all common to deepwater wells given the investment requirements) may in part contribute to lower LWC frequency.

12. Alternative methods could be used to estimate the likelihood of occurrence of a catastrophic spill from LWC based on an event tree, fault tree, bow tie or modeled approach (DNV 2010a; DNV 2010c). For example, a different means to calculate the expected frequency of LWC could follow this example event tree: frequency of LWC for a specific operational phase, factor adjustment for different incident rates by water depth, factor adjustment for not being a shallow gas blowout, factor adjustment for surface flow as compared to underground flow, factor adjustment for whether the surface release is gas or crude/condensate, factor adjustment for BOP reliability or other barriers, etc. This could then be coupled with stochastic spill size distribution modeling based on historical spill size observations, predictions of worst case discharge, and/or historical/predicted discharge durations. The DNV 2010a analysis provides a recent example in part for exploration drilling in the Canadian Beaufort Sea; following such methods, DNV calculated that the likelihood of uncontrolled flow of oil after considering certain technological barriers was 1 per 100,000 exploration wells drilled. That assessment did not address the reduced expected frequency related to varying spill sizes from an uncontrolled surface flow.
13. This analysis does not account for new risk reducing measures (including those required by new BSEE regulations) which are likely to reduce the likelihood of a blowout (DNV 2010b, c) or control its potential size (e.g., capping, containment and well control technologies). This analysis of historical OCS LWC and crude and condensate spill observations again represents a conservative approach to frame the risk.

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The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Bureau of Ocean Energy Management Mission

The Bureau of Ocean Energy Management (BOEM) manages the exploration and development of the nation's offshore resources. It seeks to appropriately balance economic development, energy independence, and environmental protection through oil and gas leases, renewable energy development and environmental reviews and studies.