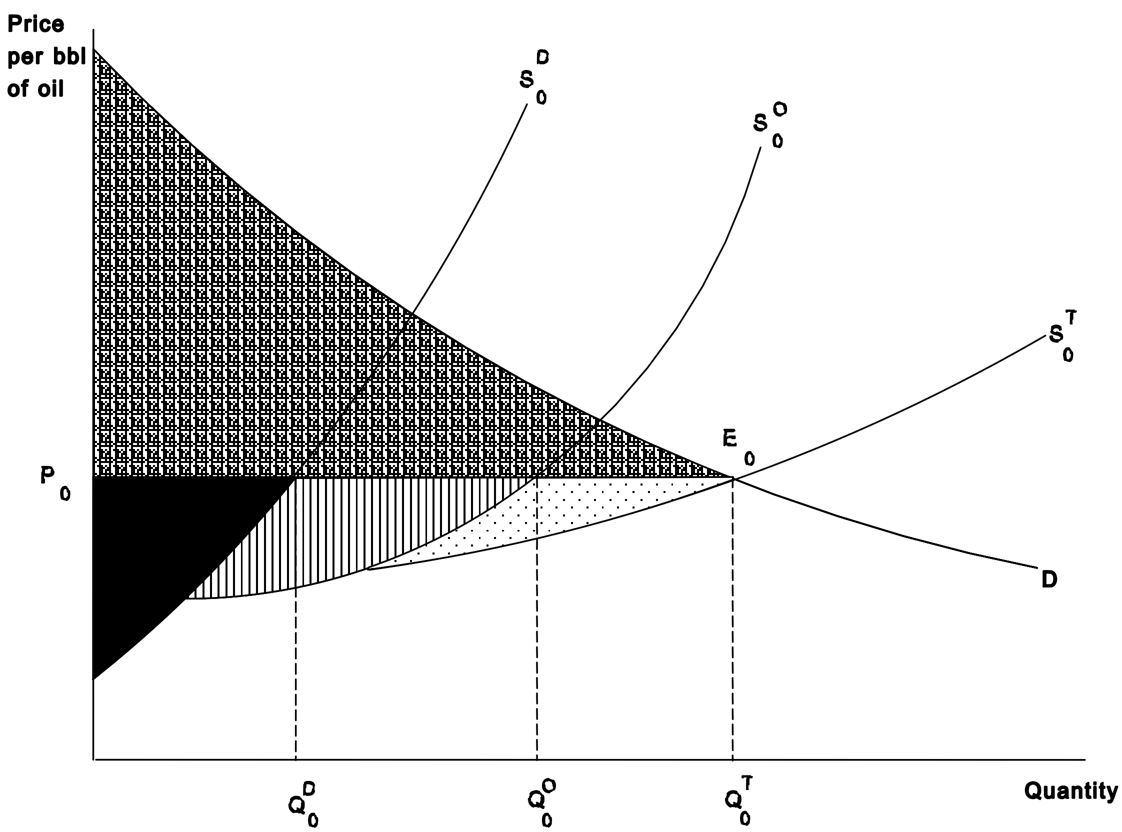
OCS Report
MMS 2007-017

Economic Analysis for the OCS 5-Year Program 2007-2012: Theory and Methodology



U.S. Department of the Interior
Minerals Management Service

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MMS 2007-017

Economic Analysis for the OCS 5-Year Program 2007-2012: Theory and Methodology

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May 24, 2007

U.S. Department of the Interior
Minerals Management Service

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 Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Minerals Revenue Management** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.

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Economic Analysis for the OCS 5-Year Program 2007-2012:

Theory and Methodology

1. Introduction

The purpose of this paper is to document the theoretical background, methodology, and results of the economic analysis performed for the *Proposed Final Outer Continental Shelf Oil and Gas Leasing Program 2007 to 2012* (*Proposed Final Program*). The economic analysis, which the Minerals Management Service (MMS) prepares, provides the Secretary of the Interior (the Secretary) with a logically consistent analytical basis for determining the timing and location of lease sales and deciding among an array of leasing alternatives. It is important at the outset to make clear that the results of the economic analysis are simply one criterion among many for choosing among the alternatives. Other valid criteria could lead the Secretary to choose an alternative other than the one that would be chosen solely on the basis of the economic analysis.

The U.S. and many other modern societies traditionally use cost-benefit analysis (CBA) as the technical basis for public decisionmaking. The courts have found the results of CBA to be appropriate grounds for the Secretary's decision about Outer Continental Shelf (OCS) leasing. Thus, the development of estimates using this approach and the Secretary's consideration of those estimates is consistent with a legally sanctioned foundation for decisions concerning OCS leasing.

The theory and practice of CBA has sanctioned a specific measure for determining the desirability of a public action. This measure is the present value of the future stream of net social benefits (gross benefits minus gross costs) from the investment or policy. In this case, the net benefits under consideration are those that would accrue to society from the OCS oil and natural gas leasing included in the *Proposed Final Program*.

The MMS divides the U.S. OCS into 26 "planning areas." However, for its economic analysis MMS considers “program areas,” rather than “planning areas.” Program areas are those portions of planning areas considered for leasing. In the *Draft Proposed Program*, MMS used a variety of technical considerations to set the location and timing of a discrete number of specific lease sales in the most promising program areas.

In the *Proposed Final Program* MMS then calculates and compares the net benefits attributable to each program area in the *Draft Proposed Program*. Because society receives benefits from past leasing and the resultant production of OCS oil and gas, only the net benefits from additional leasing (or none at all) are considered.

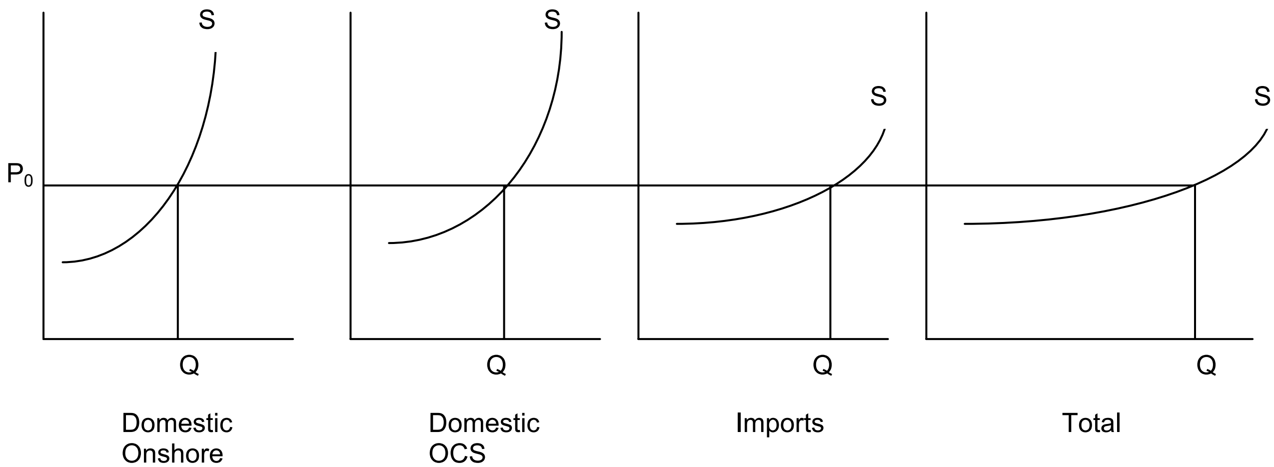
2. Theoretical Development

The methodology developed in this paper builds on the work of Boskin et al (1985), Boskin and Robinson (1987), and Rosenthal et al (1988), all of whom estimated the value of total OCS oil and gas resources. This paper also builds on previous "5-Year Programs," especially *Proposed Final Outer Continental Shelf Oil and Gas Leasing Program 2002 to 2007*.

CBA focuses on the microeconomic (market specific) benefits and costs associated with investments or policies. Complete consideration of microeconomic measures must encompass both supply and demand sides. For ease of exposition, the following discussion of these components only refers to oil; however, development of a theoretical model to estimate benefits from natural gas production would be virtually indistinguishable from that for oil.

Three sources supply the U.S. oil market: (1) domestic onshore production, (2) domestic OCS production, and (3) imports. Figure 1 shows these components summed horizontally to form the total U.S. market supply of oil. Figure 1 and all other figures and analysis in this paper assume that the international oil market acts like a locally competitive system in dealing with the relatively small shifts in international demand being analyzed here. More specifically, the paper assumes that supply curves for oil are locally continuous and upward sloping.

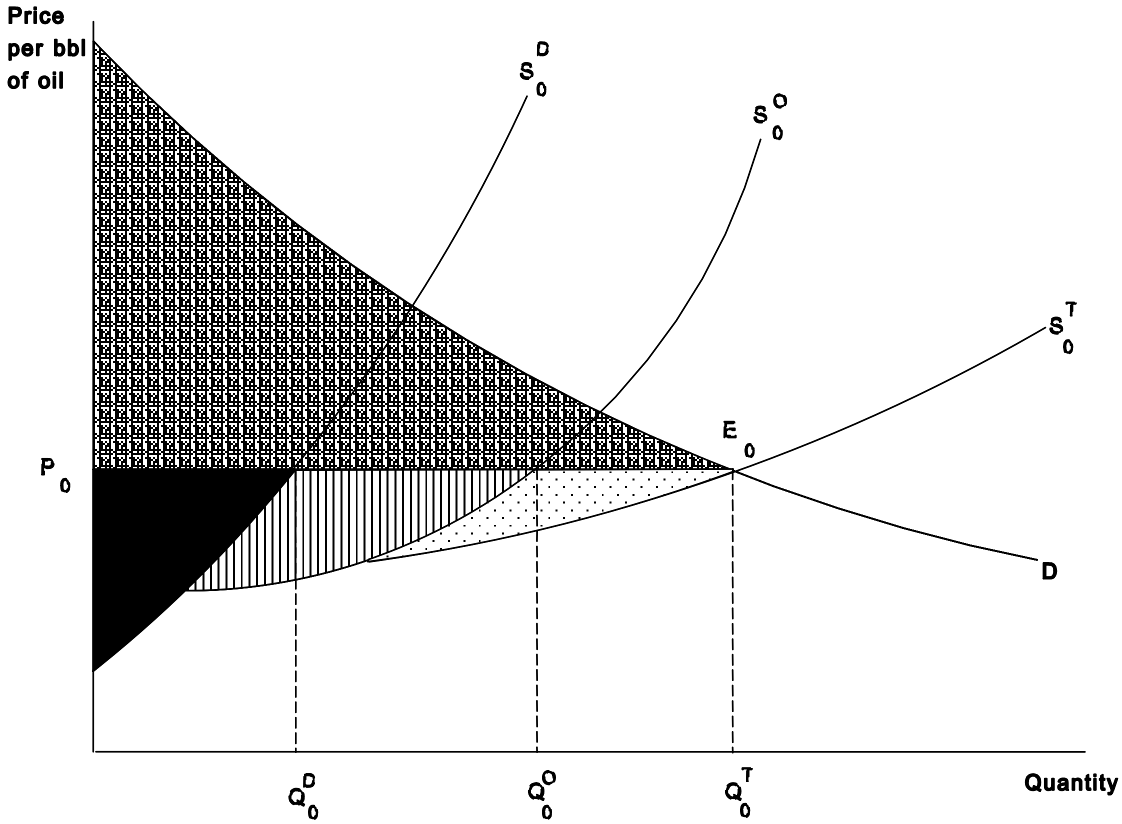
Figure 1. Components of the U.S. Oil Supply



P_0 = the price of crude oil in the initial period
S = the sectoral supply curve for oil
Q = the market clearing quantity of oil at P_0

Figure 2 provides a more detailed view of the three combined components forming a stepped envelope of supply. When U.S. demand intersects the total U.S. supply curve at E_0, domestic onshore provides *0* to Q_0^D of production, domestic OCS provides Q_0^D to Q_0^O of production, and imports provide Q_0^O to Q_0^T; however, these quantities are not drawn to an empirical scale.

Figure 2. The Combined Supply Curve for U.S. Oil



E_0 = the equilibrium in the initial period
P_0 = the market clearing price in the initial period
S_0^D = the supply curve for domestic onshore crude oil
S_0^O = the supply curve for domestic OCS crude oil
S_0^T = the supply curve for imported crude oil
Q_0^D = the market clearing quantity of domestic onshore crude oil
Q_0^O = the total market clearing quantity of domestic onshore and OCS crude oil
Q_0^T = the total market clearing quantity of crude oil
The wallpapered area = the consumer surplus
The black area = the economic rent from domestic onshore oil production
The vertically striped area = the economic rent from OCS production
The stippled area = the economic rent from imports

The initial total benefits consist of the economic rent (producer surplus) plus the consumer surplus. Economic rent is the difference between the total revenue collected by producers and their total costs of production including normal returns to labor, money, capital goods, management expertise, and other factors of production. This surplus revenue adds to the income of producers and their investors. Consumer surplus is the difference between the maximum that consumers would be willing to pay for all units up to the market clearing quantity of the good and what they actually had to pay at the market clearing price. Thus, consumers benefit by this amount compared to what they might be forced to pay in a noncompetitive economy. In figure 2, the wallpapered area above the initial price line (P_0) represents consumer surplus. The three shaded areas below P_0 represent economic rent.

Comparing the market without the OCS to the market with the OCS can help identify the benefits from domestic OCS oil production. Figure 3 illustrates the case where there is no oil production from the OCS. Compared to figure 2, the total supply curve shifts leftward by the amount of the lost OCS production and the new equilibrium occurs at E_1. Without OCS production, domestic society experiences a reduction in economic rent represented by the shaded area. This reduction is, of course, a measure of the benefit of continued OCS production.

MMS calculates a gross economic rent estimate for both oil and gas equivalent to the shaded area in figure 3 using:

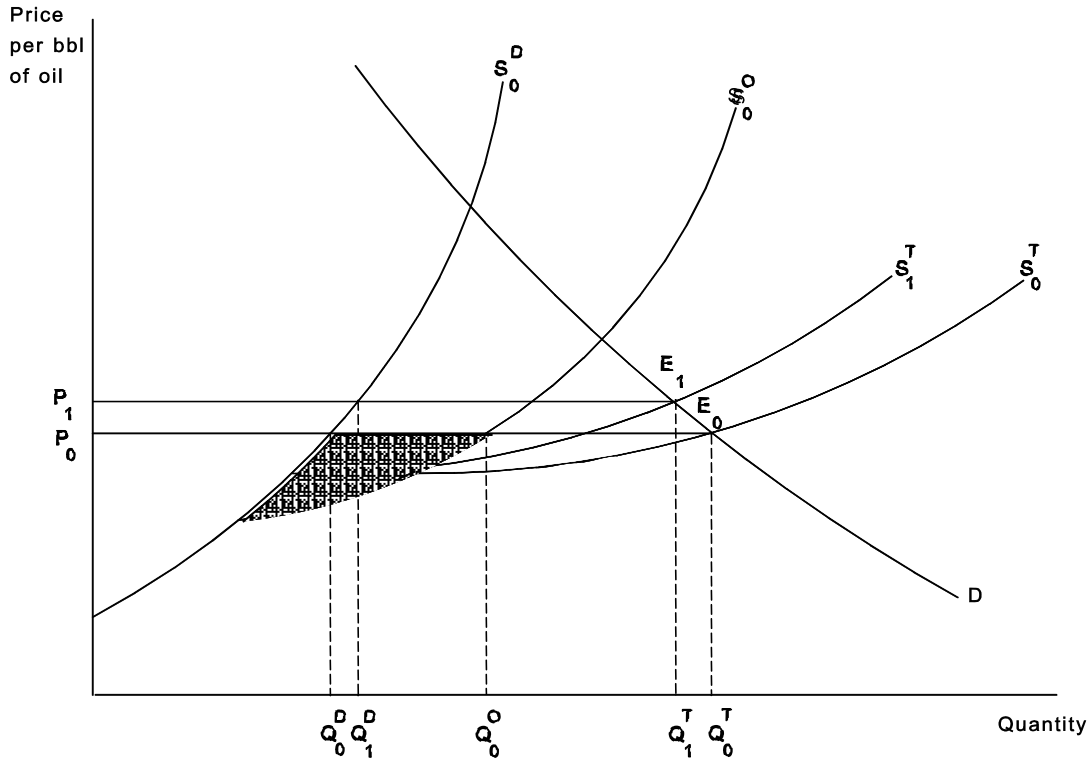
$$NEV_i = \sum_{t=1}^{n} \left[\frac{(AG_{it} \bullet PG_t) + (AO_{it} \bullet PO_t) - C_{it}}{(1+r)^t} \right] \qquad (1)$$

where:

NEV_i = the estimated net present value of gross economic rent in the ith program area. MMS calls this "net economic value," thus NEV.
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, except transfers to the government
r = a social discount rate
n = years of production associated with the leasing schedule

NEV defined this way represents the economic rent that would be realized according to a scenario of drilling and production deemed likely by MMS. Other measures of expected economic rent can be defined that account more fully for the uncertainty of future prices, costs, and other factors, and how the pace and magnitude of drilling and production might optimally respond to the potential future levels of these variables. Typically, these other measures, which reflect operator flexibility to modify plans and activities in the face of new information, provide a higher estimate of economic value than does the traditional NEV approach.

Figure 3. Without OCS Production: The Effect on Economic Rent



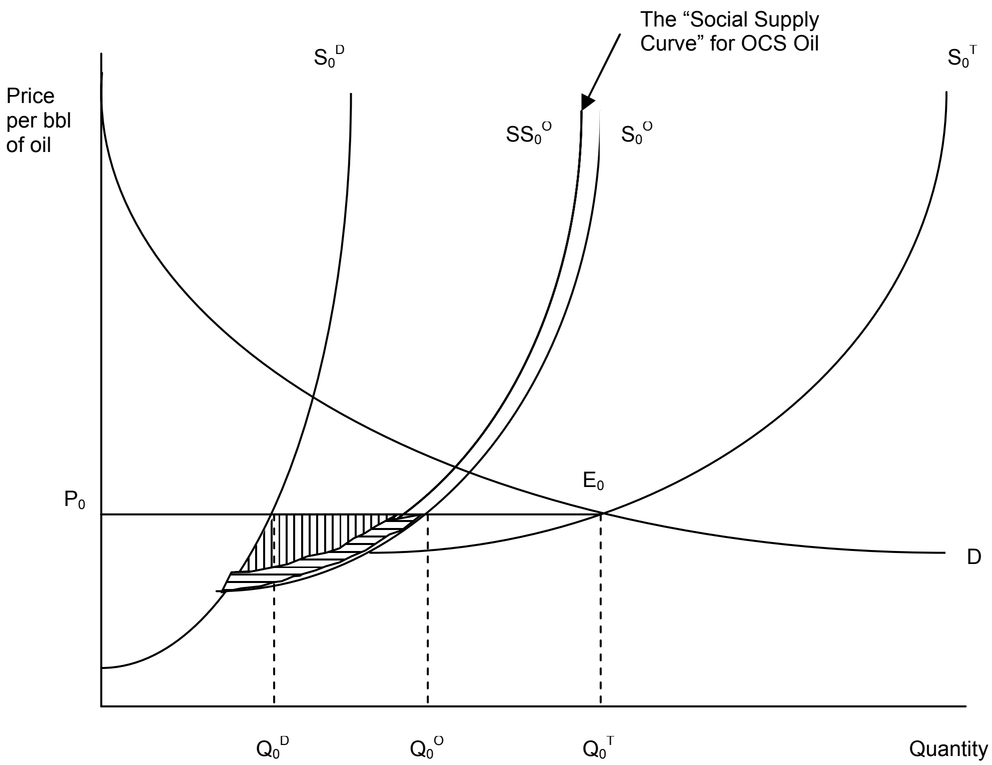
E_1 = the new equilibrium without OCS production
S_1^T = the total supply curve for crude oil without OCS production
P_1 = the new price without OCS production
Q_1^D = the market clearing quantity of domestic onshore crude oil without OCS production
Q_1^T = the total market clearing quantity of crude oil without OCS production
The wall papered area = the reduction in total economic rent without OCS production = the economic rent benefit from OCS production

Production of OCS oil imposes external environmental costs on society. These costs take the form of air pollution, risk of oil spills, pressure on overtaxed local services during development, and a range of similar impacts. Regulations have internalized many of these costs onto production firms' balance sheets; however, some persist. In figure 4, the externalities that have not been internalized are represented by an upward shift (not to scale) in the "social supply curve" of OCS oil which includes the full cost to society of producing OCS oil.

The perceived risk from environmental costs influences the political process to limit the availability of some offshore lands for oil and gas production. Nevertheless, the OCS production process is so structured that the external environmental costs associated with this process that actually occur have no measurable influence on production. Given this relationship, environmental costs reduce society's rent from OCS production as shown by the horizontally shaded area in figure 4. This leaves the net OCS economic rent represented by the vertically shaded area.

Of course, domestic onshore and imported oil also impose external costs. Indeed, a general equilibrium analysis that included all externalities associated with all substitutes and complements could lead to a somewhat different result than this paper. However, the result would probably not be significantly different than the result here.

Figure 4. Environmental Costs from OCS Production



The horizontally striped area = the environmental costs of OCS production
The vertically striped area = the net OCS economic rent

The environmental costs in program area i, E_i, equal

$$E_i = \sum_{k=1}^{s}\sum_{t=1}^{n}\left[\frac{E_{ikt}}{(1+r)^t}\right] \qquad (2)$$

where:

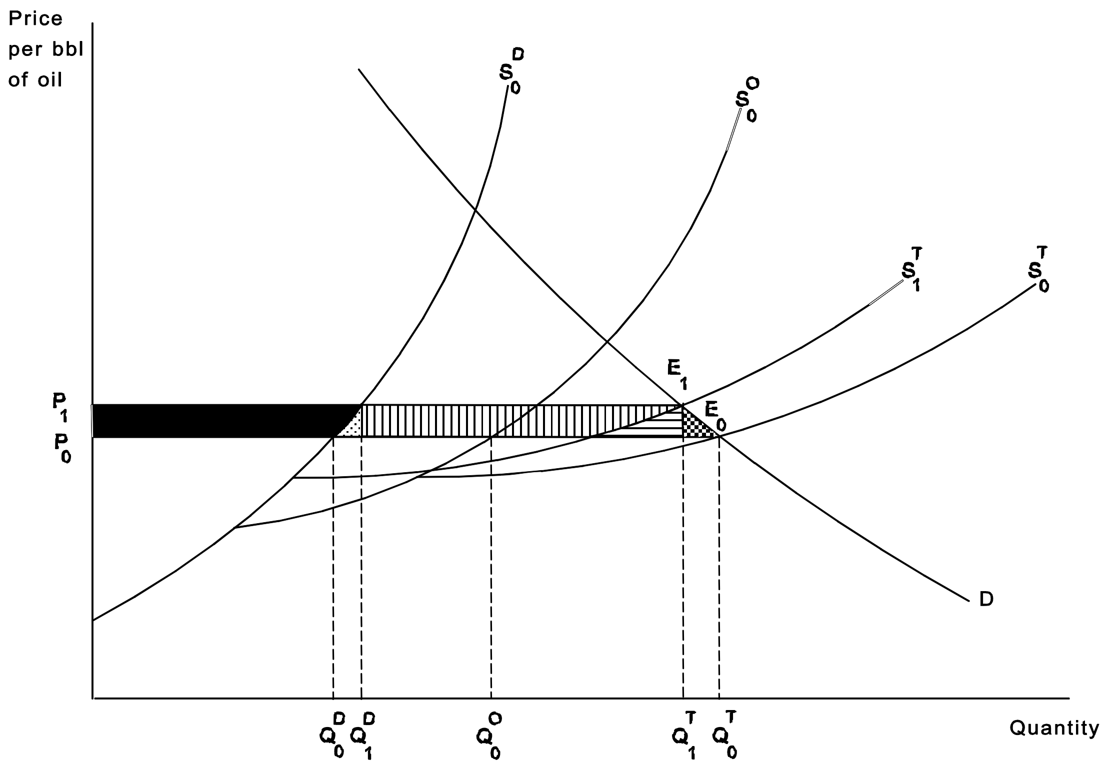
E_{ikt} = the cost to society of the kth environmental externality occurring in program area i in year t.

MMS calls the net economic rent from OCS production "net social value." This is a misnomer because it does not include consumer surplus benefits. Nevertheless, net economic rent from program area i (NSV_i) is

$$NSV_I = NEV_I - E_I \qquad (3)$$

In addition to net economic rent, OCS oil also contributes to society's consumer surplus. In figure 5 (which is similar to figure 3), without OCS oil production, consumer surplus declines as shown by the shaded areas bounded by P_1, E_1, E_0, and P_0. This occurs because when the upward sloping supply curve shifts to the left, it intersects the demand curve at a new, higher price (P_1). The higher price reduces consumer surplus.

Figure 5. Without OCS Production: The Effects on Consumer Surplus



The black shaded area = the transfer from consumers to domestic onshore producers
The stippled triangle = the additional cost of domestic onshore production
The vertically shaded area = the economic rent transferred to foreign producers of imported oil
The horizontally shaded area = the additional cost of increased foreign production
The crosshatched triangle = the net global loss of consumer surplus

However, that portion of diminished consumer surplus shaded in black in figure 5 is not lost to the U.S. economy. It is a transfer from consumers to domestic onshore producers who add it to their economic rent.

Thus, the net consumer surplus loss to the U.S. economy equals the area shaded in stippling, vertical lines, horizontal lines, and crosshatching. The stippled triangle represents the additional cost to producers of increased domestic onshore production. The vertically shaded area represents the economic rent transferred to foreign producers of imported oil. The horizontally shaded area represents the additional cost of increased foreign production. The crosshatched triangle designates the net global loss of consumer surplus.

Assuming a constant elasticity demand function of the form

$$Q_i^D = aP^\eta \tag{4}$$

where a is a constant and η is the elasticity of demand, and a constant elasticity of supply function of the form

$$Q_i^S = bP^\xi \tag{5}$$

where b is a constant and ξ is the elasticity of supply for domestic onshore oil, the U.S. consumer surplus loss from not producing on the OCS (*L*) can be expressed as

$$L_i = \int_{P_0}^{P_1} (aP^\eta - bP^\xi) dP \tag{6}$$

where the first term inside the parentheses represents the total lost consumer surplus (the shaded areas in figure V) and the second term represents the economic rent transferred to onshore oil producers (the black area). Solving equation 6 yields

$$L_i = \frac{a}{\eta + 1}(P_1^{\eta+1} - P_0^{\eta+1})\frac{b}{\xi + 1}(P_1^{\xi+1} - P_0^{\xi+1}) \tag{7}$$

which is the formula for calculating consumer surplus benefits.

As explained earlier, losses in the "without OCS case" represent the benefits of OCS production. Thus, the net benefits from OCS resources in program area i (T_i) equal the net economic rent plus the consumer surplus. Or,

$$T_i = NSV_i + L_i \tag{8}$$

3. 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, industry will be much more likely to develop hydrocarbon resources in frontier areas if industry expects future oil and natural gas prices to remain high. Scenarios must also be consistent. The MMS ensures consistency by using identical input assumptions in calculating each component of the economic analysis. The analysis in the environmental impact statement (EIS) that accompanies the program decision document also uses the same set of assumptions as the net benefit analysis. Five subsets make up the full assumption set for the economic analysis.

For the *Proposed Final Program* analysis, the assumption set is:

- oil and natural gas prices
- the discount rate
- anticipated production
- exploration and development scenarios
- production profiles

3.1. Oil and Natural Gas Prices

MMS has chosen to base its estimates of anticipated production, exploration and development scenarios, and economic analysis on an oil price of $46 per barrel (bbl) and a natural gas wellhead price of $6.96 per mcf. While these prices are somewhat below recent open market prices, they are thought to represent a realistic estimate of the kind of long-term prices the oil and gas industry will be using for making its development decisions. Inflation-adjusted, or "real" prices are assumed to remain constant throughout the productive life of all leases resulting from the new 5-year program.

3.2. The Discount Rate

Based on a review of the literature, familiarity with returns to the industry, and the rate used in other economic analyses, the MMS chose a discount rate of 7 percent for the *Proposed Final Program* analysis.

3.3 Anticipated Production

Resource estimates from the 2005 National Assessment form the basis for MMS's evaluation of the *Proposed Final Program*. The National Assessment projects the undiscovered, conventionally and economically recoverable oil and natural gas resources located outside of known oil and gas fields on the U.S. OCS. The assessment considers recent geophysical, geological, technological, and economic information and uses a play analysis approach to resource appraisal. A complete description of the methodology and results of resource estimation is available in the MMS report *Outer Continental Shelf Petroleum Assessment 2005*, which may be accessed on the Internet at *www.mms.gov/revaldiv/RedNatAssessment.htm*.

The net benefit analysis uses anticipated production as its key empirical input. Anticipated production is the estimated quantity of oil and natural gas that will be produced as a result of the lease sales included in the *Proposed Final Program* if production occurs.

The MMS Exploration, Development, and Production (EDP) Model combines National Assessment data with historical production, drilling, platform installation, and field discovery rate information to derive estimates of oil and gas activity levels and anticipated production from future discoveries for each program area. Anticipated production estimates calculated using the EDP provide the key input for valuation of the *Proposed Final Program* and EIS analyses. Table 1 shows anticipated production estimates for program areas included in the *Proposed Final Program*.

Table 1. Anticipated Production

Program Area	Oil (BBO)*	Gas (Tcf)*
Central Gulf of Mexico	5.604	23.707
Western Gulf of Mexico	2.021	16.200
Cook Inlet	0.200	0.200
Beaufort Sea	1.000	0.000
Chukchi Sea	1.000	0.000
North Aleutian Basin	0.200	5.000
Mid-Atlantic	0.056	0.327

*Oil estimates are expressed in billions of barrels (BBO); natural gas estimates are expressed in trillions of cubic feet (Tcf).

3.4. Exploration and Development Scenarios

Associated with various levels of production are activities and facilities related to exploring for and developing oil and gas resources. The list of these activities and facilities is called an exploration and development (e&d) scenario. It is these activities and facilities that produce oil and gas, cost money, and cause environmental and social impacts. Table 2 shows the e&d scenario attributable to each program area included in the *Proposed Final Program*.

3.5. Production Profiles

Production profiles (also called production schedules) show the distribution of anticipated production by year over the life of program related activity in each program area. The production profiles are not shown because they are lengthy and of limited interest.

Table 2. Exploration and Development Scenario

Variables	Gulf of Mexico		Alaska				Atlantic
	Central	Western	Cook Inlet	Beaufort Sea	Chukchi Sea	North Aleutian	Mid-Atlantic
No. of sales	5	5	2	2	3	2	1
Anticipated Production-oil (BBO)	5.604	2.021	0.200	1.000	1.000	0.200	0.056
Anticipated Production-gas (Tcf)	23.707	16.200	0.200	0.000	0.000	5.000	0.327
Years of activity	40	40	30	40	40	40	40
No. of platforms	201	299	2	5	5	6	2
No. of exploration & delineation wells	703	606	10	16	14	20	5
No. of development & production wells	2,110	1,361	100	222	178	200	12
Pipeline miles	1,465	1,540	200	150	450	200	90
No. of landfalls	0	0	2	1	2	2	1

Oil estimates are expressed in billions of barrels (BBO); natural gas estimates are expressed in trillions of cubic feet (TCF).

4. Models and Results

The total net benefits from OCS production include net economic rent and consumer surplus for both oil and natural gas. Section 2 of this paper refers primarily to benefits from oil. This simplifies the theoretical discussion because similar theoretical analysis applies to natural gas. Empirically, however, differences arise between the two resources. The differences are identified below.

4.1. Net Economic Rent

Following equation 3, net economic rent consists of the gross economic rent minus the environmental and social costs associated with production. Graphically, the vertically shaded area in figure 4 represents net OCS economic rent.

4.1.1. Net Economic Value

Net economic value (NEV) is the difference between the discounted gross market value of total resources or anticipated production and the discounted real cost of exploring, developing, producing, and transporting the product to market (except for transfers to the Government). The U.S. Government (the lessor) collects a portion of the NEV as transfer payments in the form of cash bonuses, rentals, royalties, and taxes. The lessees (private firms) retain the remainder of the NEV as economic profits.

The NEV's of the planning areas are calculated using a discounted cash-flow model called NEV. NEV calculates the gross value of anticipated production in a planning area based on expected oil and gas prices. The gross value of the production is then discounted so that values can be expressed in terms of a 2007 program starting date. Likewise, the costs of exploration, development, production, and transportation (excluding transfer payments) are calculated and discounted back to 2007. The discounted costs are then subtracted from the discounted gross production value. This difference represents the NEV, as of 2007, for the planning areas. Table 3 includes NEV's for the program areas included in the *Proposed Final Program*.

4.1.2. Environmental and Social Costs

The net economic value assessment considers the private costs, except for transfer payments to the Government, incurred by the firms that discover and develop OCS oil and natural gas resources. In addition, society incurs environmental and social costs from the activities and facilities associated with OCS oil and natural gas production. These costs take a variety of forms and the MMS has organized the environmental and social costs associated with OCS activities into the following nine categories:

- Beach Recreation
- Recreational Fishing
- Ecological
- Commercial Fisheries
- Subsistence
- Air Quality
- Public Service
- Property Values
- Water Quality

The general public views oil spills as the most serious risk 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, etc.

Fortunately, the environmental and social costs associated with several oil spills have been relatively well documented so there is a reasonable basis for oil-spill cost modeling in the literature. Nevertheless, modeling efforts are usually limited to assessing the effects of an "average" event like an oil spill. In the case of the analysis performed for this report, the estimates are for the aggregate costs of all the spills that the model suggests would most likely result from anticipated production. This approach cannot and does not try to measure the effects of any individual spill, nor does it take into account the unlikely event of a catastrophic spill of unprecedented proportions.

If OCS oil and, to a lessor 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 environmental costs. Subtracting the environmental costs associated with these increased imports from the environmental costs associated with OCS production leaves an estimate of the net environmental and social costs associated with OCS activities. To ensure consistency, MMS employs the MarketSim model to estimate imports that would substitute for OCS production. MarketSim also estimates consumer surplus benefits and provides energy substitution estimates for the no action alternative in the EIS and the energy alternatives evaluation.

The MMS uses the Offshore Environmental Cost Model (OECM) for estimating environmental and social costs associated with OCS activities. The OECM is designed to model the impact of typical activities associated with OCS production and typical oil spills occurring on the OCS. This model is not designed to represent impacts from global climate change, catastrophic events, or impacts on unique resources such as endangered species. The reader is referred to the EIS accompanying the decision document for assessment of global climate change, catastrophic effects, and impacts on unique resources. Decisionmakers are cautioned that the environmental and social costs included in this analysis are not necessarily all the costs that might be associated with the proposed action and other options, although the MMS attempted to assess accurately all reasonably expected costs.

The OECM is a 9-sector spreadsheet model. The nine sectors are the same as those listed above as the categories of environmental and social costs. The model uses economic inputs, anticipated production, and e&d scenarios as the basis for its calculations.

Both the gross environmental and social costs and the costs of replacement imports have been allocated to the planning areas on the basis of production. The rationale for this decision is twofold. First, all benefits are allocated to the planning areas where the production occurs; therefore, it would be inconsistent to do otherwise for costs. Second, and more importantly, if benefits and costs are not allocated to the area of production, it would be nearly impossible to maintain the cause-and-effect link between a decision to lease in a specific planning area and the costs and benefits likely to result from that decision.

The OECM uses habitat equivalency analysis to overcome the problem of passive enjoyment value. Passive enjoyment value, also called passive use or non-use, is the benefit people derive from: (1) knowing a natural resource continues to exist in a specific condition, (2) retaining the option to use that resource in the future, and (3) being able to pass the resource to future generations (which may be a subset of (2)). Passive enjoyment value represents an important component of the value of natural resources; however, it is very difficult and extremely expensive to measure accurately. Some economists question whether it ever can be measured accurately. Exacerbating the difficulty and expense of estimating passive enjoyment is the complication imposed on measurement by the vast extent of territory, many program areas, and great diversity of natural resources covered by this program. Habitat equivalency analysis avoids the passive enjoyment problem by estimating the cost of providing additional habitat equivalent to that lost from an environmental event such as an oil spill. Table 3 includes net environmental and social costs for program areas included in the *Proposed Final Program*.

4.2. Consumer Surplus

The MMS calculates consumer surplus benefits associated with anticipated production using the MarketSim model. As mentioned in section 4.1.2, in order to maintain consistency, this same model with the same assumptions is used for other portions of the 5-Year Program analysis. MarketSim includes submodels for oil and natural gas.

4.2.1. Consumer Surplus -- Oil

Consumer surplus attributable to OCS production is represented graphically by the areas shaded in stippling, vertically, horizontally, and crosshatching in figure 5. The equation that forms the basis for the oil submodel in the market simulation model includes a shift in oil price analogous to the price change in figure 5. Oil prices are set on a world market. Simulating a shift in world oil market equilibrium entails a simultaneous model with multiple sectors of demand and supply. However, obtaining information from many different sources compounds the data compatibility problem in an effort such as this one. Thus, this paper limits input data to five sources. Among these are the anticipated production estimates, e&d scenarios, and production profiles developed and modified by the MMS. Another source is data found in the U.S. Department of Energy, Energy Information Administration *Annual Energy Outlook 2006 with Projections to 2030* (DOE (2006)). The final source is a set of demand and supply elasticity estimates developed by Foster Associates (Foster (2000)).

DOE (2006) reports international oil production and consumption for an array of geographical regions. The regions on the production side were combined to form three: United States, OPEC, and Rest of World. The U.S. estimate was divided into OCS and onshore domestic to make a total of four production sectors. The consumption estimates were combined to form United States, Other OECD, OPEC, and Rest of World. Thus, the model contains four production and four consumption sectors for which Foster (2000) provides elasticity estimates. Retaining the constant elasticity functional form for the demand and supply sectors, the world oil market is represented by the following simultaneous system:

$$
\begin{aligned}
Q^{OCSS} &= b^{OCSS} P_0^{\xi^{OCSS}} \\
Q^{ODOMS} &= b^{ODOMS} P_0^{\xi^{ODOMS}} \\
Q^{OPECS} &= b^{OPECS} P_0^{\xi^{OPECS}} \\
Q^{ROWS} &= b^{ROWS} P_0^{\xi^{ROWS}} \\
Q^{USD} &= a^{USD} P_0^{\eta^{USD}} \\
Q^{OECDD} &= a^{OECDD} P_0^{\eta^{OECDD}} \\
Q^{OPECD} &= a^{OPECD} P_0^{\eta^{OPECD}} \\
Q^{ROWD} &= a^{ROWD} P_0^{\eta^{ROWD}} \\
Q^{OCSS} + Q^{ODOMS} + Q^{OPECS} + Q^{ROWS} &= Q^{USD} + Q^{OECDD} + Q^{OPECD} + Q^{ROWD}
\end{aligned}
\tag{9}
$$

Where the first four equations are the sectoral supply equations, the second four are the sectoral demand equations, and the last is the world oil market equilibrium equation.

The first step in calculating consumer surplus is to solve for the sectoral constants (a^s and b^s) in each of the demand and supply equations. Input to these equations consists of oil price, production quantity, and consumption quantity projections from DOE (2006), plus the elasticity estimates from Foster (2000).

The model then introduces the sectoral constants back into the equation system, sets Q^{OCSS} to zero, and solves the system. The products of the solution are a new price without OCS production (P_1) and a new set of sectoral quantity estimates. The model next calculates consumer surplus using equation 7 where the a and the η are from the *USD* equation and the b and the ξ are from the *ODOMS* equation. It performs this sequence of actions for each year in the analysis period. The yearly estimates are allocated to planning areas on the basis of the anticipated production in each planning area in that year. Finally, the model takes the net present value of each vector of consumer surplus estimates allocated to each planning area.

4.2.2. Consumer Surplus -- Natural Gas

The natural gas submodel uses the same sources of input data as the oil submodel. However, unlike oil, imports constitute a relatively small fraction of U.S. natural gas consumption. As a result, the natural gas submodel includes only three production sectors (OCS, onshore domestic, and imports) and only a single domestic consumption sector. A second difference with oil is that the wellhead price of gas drives production while the delivered price drives consumption and the trends in these two prices may diverge. Therefore, the U.S. natural gas market can be represented by system 10

$$
\begin{aligned}
Q^{OCSS} &= b^{OCSS} P_{W0}^{\xi^{OCSS}} \\
Q^{ODOMS} &= b^{ODOMS} P_{W0}^{\xi^{ODOMS}} \\
Q^{IMPRTS} &= b^{IMPRTS} P_{W0}^{\xi^{IMPRTS}} \\
Q^{USD} &= a^{USD} P_{D0}^{\eta^{USD}} \\
Q^{OCSS} + Q^{ODOMS} + Q^{IMPRTS} &= Q^{USD} \\
P_{D0} &= P_{W0} + \lambda
\end{aligned}
\qquad (10)
$$

where the first three equations are the sectoral supply equations, the fourth is the U.S. demand equation, the fifth is the market equilibrium equation, and the last is the price reconciliation equation in which λ equals the difference between wellhead and delivered natural gas prices.

The natural gas submodel follows the same steps as the oil submodel. The market simulation model adds the totals from oil and natural gas submodels to get total consumer surplus benefits. Oil and gas results for relevant program areas are included in table 3.

5. Net Benefit Analysis

The ultimate purpose of the economic analysis for the new 5-Year Program is to help the Secretary select the best schedule of proposed sales. Those program areas with positive net benefits are appropriate for inclusion in the leasing program from an economic point of view. It should be remembered that decisionmakers can and should bring to their decisions other valid points of view besides economics. In other words, positive net benefits ought not to be the sole criterion for selecting any particular option or for including or excluding a program area from the leasing schedule.

5.1. Program Area Total Net Benefits

The sum of supply- and demand-side net benefits constitutes the total net benefits associated with anticipated production from planning areas included in the *Proposed Final Program*. Table 3 shows the estimates of the components of the net benefit analysis for the program areas in the *Proposed Final Program*.

5.2. Valuation of the *Proposed Final Program*

As mentioned above, the MMS has chosen a proposed program for analysis in the 5-Year Program process. Table 4 shows the areas and sales being considered for the *Proposed Final P:rogram.*

Table 3. Program Area Net Benefits

Program Areas	Net Economic Value	Environmental Costs	Net Social Value	Consumer Surplus Benefits	Net Benefits
Central Gulf of Mexico	87.66	0.3375	87.32	12.20	99.52
Western Gulf of Mexico	39.36	0.2733	39.09	5.35	44.44
Cook Inlet	1.11	0.0156	1.09	0.29	1.38
Beaufort Sea	5.33	0.0465	5.28	1.30	6.58
Chukchi Sea	3.79	0.0463	3.74	2.63	6.37
North Aleutian	5.48	0.0129	5.47	2.23	7.70
Mid-Atlantic	0.20	0.0018	0.20	0.15	0.34

All figures in the table are in billions of 2007 dollars.

Table 4. The Lease Sale Schedule for Available Areas

Sale No.	Area	Year
204	Western Gulf of Mexico	2007
205	Eastern Gulf of Mexico	2007
205	Central Gulf of Mexico	2007
193	Chukchi Sea	2007
206	Central Gulf of Mexico	2008
207	Western Gulf of Mexico	2008
208	Central Gulf of Mexico	2009
209	Beaufort Sea	2009
210	Western Gulf of Mexico	2009
211	Cook Inlet	2009
212	Chukchi Sea	2010
213	Central Gulf of Mexico	2010
215	Western Gulf of Mexico	2010
216	Central Gulf of Mexico	2011
217	Beaufort Sea	2011
218	Western Gulf of Mexico	2011
219	Cook Inlet	2011
221	Chukchi Sea	2012
222	Central Gulf of Mexico	2012

Potential Lease Sale Schedule for Areas Subject to Restrictions*

Sale No.	Area	Year
214	North Aleutian Basin	2010
220	Mid-Atlantic	2011
223	North Aleutian Basin	2012

*Lease sales would only be held if the President chooses to modify the withdrawal in both areas and Congress discontinues the annual statutory moratorium in the Mid-Atlantic. The potential Mid-Atlantic sale scheduled for 2011 will only cover a small part of the planning area, a wedge-shaped piece off the coast of Virginia.

A crucial alternative to this schedule is no action, which is an alternative that must be analyzed in the environmental impact statement that accompanies the *Proposed Final Program*. MMS uses the net benefits attributable to each program area, shown in Table 3, to compute the net benefits for the program alternatives being considered in the *Proposed Final Program.* Table 5 shows the values attributable to each of these alternatives.

TABLE 5. Valuation (Net Benefits) of Program Alternatives

Program Areas	Net Economic Value	Environmental Costs	Net Social Value*	Consumer Surplus	Net Benefits *
Alternative 1 (Proposed Action)	$142.93	$0.73	$142.19	$24.15	$166.34
Alternative 2 (Exclude North Aleutian Basin)	$137.45	$0.72	$136.72	$21.94	$158.66
Alternative 3 (Exclude Cook Inlet)	$141.82	$0.71	$141.10	$23.86	$164.96
Alternative 4 (Exclude Mid-Atlantic)	$142.73	$0.73	$141.99	$24.00	$165.99
Alternative 5 (Defer Blocks within 25 Miles of Virginia and Chukchi Sea Coasts)	$142.93	$0.73	$142.19	$24.15	$166.34
Alternative 6 (Exclude Blocks at Mouth of the Chesapeake Bay)	$142.93	$0.73	$142.19	$24.15	$166.34
Alternative 7 (Limit Leasing in the North Aleutian Basin to Blocks Offered in Sale 92)	$142.93	$0.73	$142.19	$24.15	$166.34
Alternative 8 (Defer Blocks in the Beaufort Sea to Avoid Conflicts with Whaling)	$142.93	$0.73	$142.19	$24.15	$166.34
Alternative 9 (Defer Blocks within 50 Miles of Virginia with Possible other Restrictions)	$142.93	$0.73	$142.19	$24.15	$166.34

All figures in the table are in discounted billions of 2007 dollars. All benefits and environmental costs are relative to Alternative 10 (the No Action alternative), the costs of which are primarily due to increased onshore production and oil imports, most of which would be transported to the U.S. by supertankers. Although the changes inherent in alternatives 5-9 could reduce available resources, given the location of likely exploration, development, and production activities, MMS believes that they probably would not reduce anticipated production and the resulting net benefits.
* Net Social Value and Net Benefits estimates in Table 5 were calculated using the numbers in Table 3. This may have produced slight rounding errors in the Net Economic Value and/or Net Social Value estimate shown in Table 5.

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