# APPENDIX B

# EXPLORATION AND DEVELOPMENT SCENARIOS

# EXPLORATION AND DEVELOPMENT SCENARIOS

Section 2.4 discusses the scenario framework developed for this EIS. The primary purpose of the scenarios in this document is to provide a common basis for analysis of potential environmental impacts associated with future activities, assuming these activities occur as presented in the scenario.

The scenarios are hypothetical. We assume a reasonable scale of development considering the petroleum potential, available technologies and industry trends. The EIS scenarios, although subjective, are based on professional judgment and as much information as possible, including petroleum geology, engineering and technology, and economic trends. The scenarios are generalized, because the size and location of future commercial pools are unknown at the present time. Scenarios are not intended to be firm predictions. Actual operations will be conducted according to site-specific conditions, and no one can identify these locations at the present time.

All scenarios are hypothetical, but they can be described as *reasonably foreseeable* or *speculative*. A *reasonably foreseeable* scenario is interpreted here to mean a continuation of current trends into the near-term future. The timeframe considered to be "foreseeable" is not fixed, and is based on professional judgment and the availability and reliability of relevant information. Clearly, the shorter the timeframe, the more likely that predictions will be accurate. In contrast, a *speculative* scenario would involve a significant change from historical trends or timeframes beyond several decades into the future. Speculative scenarios are much more uncertain, because there is no accurate way to define the timing or characteristics of operations in the distant future, particularly when projects could require technologies that are unknown today. NEPA requires analysis for reasonably foreseeable impacts (40 CFR 1502.22), and by inference reasonably foreseeable activities. NEPA does not require analysis of speculative activities. However, for purposes of analysis and in the spirit of full disclosure, this EIS describes and evaluates the potential impacts of the full range of activities that may result a proposed leases sale, including speculative development, production, and abandonment activities.

Exploration activities are classified in our analysis as being reasonably foreseeable, because it is logical to assume that when companies buy leases, they will try to explore their leases. Primary lease terms are typically 10 years, so exploration operations will take place within the foreseeable timeframe. If commercial discoveries are not made within the primary lease term, the tracts are relinquished to the Federal Government and could be offered at a later lease sale. Exploration operations (marine seismic, well drilling, and ancillary activities) have occurred for several decades in the areas, so the characteristics of these activities are well known. We also include development of some discoveries in the reasonably foreseeable scenario, because high current oil prices might justify their development.

Development activities are described as being speculative because offshore facilities have only been installed in nearshore areas of the Beaufort, and none have been installed in the Chukchi. Development throughout these OCS areas would be a change from historical trends over the past 3 decades. Although exploration technologies have advanced, many of the large geologic prospects have been drilled without making commercial discoveries. Although these areas are only partly tested (36 wells have been drilled in planning areas), the challenges that have hindered past operations also are likely to affect future operations. The high petroleum resource potential in the Beaufort Sea and Chukchi Sea undoubtedly will attract industry interest in leasing and exploration, but development will not occur unless the current economic, engineering, and regulatory impediments are overcome.

Both the Beaufort and Chukchi provinces could contain large amounts of oil and gas. The 2006 petroleum assessment conducted by MMS (USDOI, MMS, 2006e) estimated that these two areas could hold mean technically recoverable oil resources of 23 billion barrels (Bbbl) (85% of the entire Alaska

OCS) and the mean technically recoverable gas resources of 105 trillion cubic feet (Tcf) (80% of the entire Alaska OCS). Although these resource numbers are impressive, resource potential should not be confused with proven reserves. Undiscovered *resources* have not been located and, when discovered, they must be feasible to develop to become producing fields. *Reserves* are proven oil and gas accumulations that are feasible to recover with a profit acceptable to the field operator. Typically, a large portion of the petroleum potential could occur in pools that are too small, too hard to identify, or too costly to develop. This portion of the resource potential is unlikely to become producing reserves, because companies will not purposely develop uneconomic projects. It also is unlikely that industry will test all of the pools mapped in an area, because this would require hundreds of wells and the cost would be prohibitive. A more realistic view is that industry will high-grade mapped prospects and drill the largest pools first. If commercial discoveries are made, these first projects would become infrastructure hubs around which smaller fields could be developed later. The development history of the North Slope is a good example of this typical development trend (biggest-first) in a frontier area.

The Chukchi OCS is viewed as one of the most petroleum-rich offshore provinces in the U.S., with geologic plays extending offshore from some of the largest oil and gas fields in North America on Alaska's North Slope. The MMS 2006 assessment (USDOI, MMS, 2006e) for the Chukchi Sea area indicates that a mean resource potential of 15.38 Bbbl of oil could be recoverable using current technologies. The mean oil resource potential is modeled to occur in a mean (average) number of 154 pools grouped into 27 different geology plays. To have a realistic chance of commercial development, oil prices must be high enough to cover the high costs for operations. The 2006 assessment indicates that there are no economically recoverable resources in this area at oil prices lower than $40/bbl. This fact highlights the investment risk faced by industry because the average price for North Slope crude oil over the past 10 years has been $31.16 (ADNR, 2007d). Assuming that commercial-size discoveries are made and future prices average $60/bbl (in constant dollars) over the next several decades, the assessment indicates that 7.05 Bbbl (about 46% of the conventionally recoverable endowment) could be viable to develop, if discovered. Higher average oil prices would increase the amount of oil that is recoverable but does not necessarily increase the level of exploration because costs also increase with higher prices.

## Scenarios for the Arctic OCS.

The timing and location of future activities will depend on many factors, the most important of which are the physical challenges of the arctic environment (extreme seasonal conditions); technology advancements to operate safely in a difficult new setting; regulatory constraints (access to prime exploration areas); industry funding (bidding in lease sales, exploration drilling); and commodity prices (to support high-cost activities). Most blocks in the lease sale areas probably will experience little or no activity. Reviewing the history of the Beaufort Sea OCS, 10 OCS lease sales have been held since 1979. Only a small fraction of the blocks offered (15,353 blocks) were leased by industry (929 leases, or 6% of the blocks offered). Even fewer of the leases were tested by drilling. Exploration drilling rates are rather slow (31 wells since 1979). Thirty-one exploration wells tested 20 prospects (1 well per 30 leases). Nine of the exploration wells were classified as discoveries (capable of producing in paying quantities), confirming that potentially commercial pools occur in six prospects. Only one of the six (17%) potentially commercial discoveries has been developed (Northstar). Thus, the commercial success rate for the prospects tested is 5% (1/20). The commercial success rate for all blocks leased is only 0.01%. It is obvious that leasing is a poor indication of the scale of subsequent commercial development.

As a result of nearly 30 years of leasing and exploration activities, three production facilities have been installed on artificial gravel islands in the Beaufort Sea. The Endicott field was the first offshore facility in State waters (2-miles [mi] offshore), and 2 gravel islands are connected to shore by a causeway. The

Northstar field was the second offshore facility and produces a small amount of oil (approximately 18% of the 208-MMbbl field) from OCS tracts by wells drilled from a gravel island in State waters (5-mi offshore). The Oooguruk field is the third nearshore project and will produce oil from an artificial gravel island located 3 mi offshore in 5 feet (ft) of water. Plans for the offshore Liberty field now include using ultra-long reach wells drilled from the Endicott facility to recover oil from adjacent Federal tracts.

The history of these fields illustrates the difficulties faced by operations in Arctic waters. The Endicott field was discovered in 1978 and production start-up occurred 1986 (8 years later). The Northstar field was leased in 1979, discovered in 1984 (formerly called Seal Island), and production start-up was in 2001 (17 years after discovery). The Oooguruk field was discovered in 2003 and will start-up in 2008 (5 years after discovery). The Liberty field was leased in 1979, discovered in 1982 (formerly called Tern Island), and production startup is planned for 2011 (29 years after discovery). Compared to these nearshore (<5 mi) shallow-water (<40 ft) projects, the challenges facing new projects in remote (>50 mi) and deeper water (>100 ft) areas will be far more difficult.

It is important to remember that our scenarios are not arbitrary and they are based on petroleum resource assessments and industry trends. The Chukchi Sea can be used as an example. The MMS 2006 assessment (USDOI, MMS, 2006e) for the Chukchi reports that a mean resource potential of 15.38 Bbbl of oil could be recoverable using current technologies. This oil potential is modeled to occur in a mean (average) number of 154 pools grouped into 27 different geology plays. To have a realistic chance for commercial development, oil prices must be high enough to cover the high costs for operations. The 2006 assessment indicates that there are no economically recoverable resources in this area at oil prices lower than $40/bbl. This fact highlights the investment risk faced by industry because the average price for North Slope crude oil over the past 10 years has been $31.16 (ADN, 2007d). Assuming that commercial-size discoveries are made and future prices average $60/bbl (in constant dollars) over several decades, the assessment indicates that 7.05 Bbbl (about 46% of the conventionally recoverable endowment) could be viable to develop after it is discovered. Even higher average oil prices would increase the amount of oil that is recoverable but may not increase exploration effort because drilling costs also increase with higher prices and many regulatory hurdles are present. The first question is: how much could be discovered?

We can assume that with the high costs of exploration wells (over $50 million per well), companies will be selective about the prospects they chose to drill. Industry probably will focus on the largest prospects, because large volumes have the best chance of commercial success. Because there is no infrastructure, the first stand-alone field in the Chukchi may need to contain 1 Bbbl (or more) to justify development. The 2006 assessment indicates that 13 oil pools of this size could be present in the group of 154 pools that represent the mean undiscovered oil potential. The engineering simulation in the 2006 assessment indicates that a mean number of 73 exploration wells would be required to discover the mean economic oil endowment. Discovering 13 large pools with 73 exploration wells implies an 18% success rate, which is fairly typical of a rich frontier basin.

The next question is: how many wells is industry likely to drill? As a result of two previous lease sales in the Chukchi OCS, five exploration wells were drilled from a total inventory of 483 leases (or 1% of the blocks leased). These first exploration wells tested some of the largest mapped prospects in the area. Although there are many other untested prospects in the area, it is optimistic to think that industry will drill 73 more wells in this very high-cost area (well costs could be $50-$70 million per well). Using the historical drilling rate in the Arctic OCS over the last 3 decades (approximately 1 well/year), we can assume that industry would drill 10 more exploration wells as a result of a series of lease sales scheduled for the Chukchi OCS. If discovery efficiency is directly correlated to the number of wells, 10 exploration wells could translate into the discovery of 14% (10/73) of the economically recoverable resources,

amounting to 1 Bbbl of the total of 7 Bbbl assessed for this area. This reasoning is used to generate the scenario, where a single standalone field with 1 Bbbl is assumed to be discovered and developed in the Chukchi after lease sales beginning in 2008 (Sale 193). Until this standalone, or "anchor" field is in operation, the Chukchi will remain an undeveloped frontier area.

Our scenarios are considered as being optimistic because we assume that all of the discoveries will be developed as commercial projects. However, different companies could have higher standards for a commercial project, and marginally economic or difficult projects may not be developed even though they are theoretically viable. Only 1 of the 6 discoveries in the Beaufort and Chukchi OCS has been developed (Northstar) to-date. The discovery of a potentially commercial pool is just the beginning of a lengthy regulatory process and higher expenditures by industry. Numerous factors (availability of funding, engineering feasibility, regulatory hurdles) could easily delay or cancel development of a promising discovery.

A preliminary petroleum development scenario for the Beaufort and Chukchi OCS was previously assumed for the Programmatic EIS for the 2007-2012 5-Year Program (USDOI, MMS, 2007c). Table B-1 lists the production and associated infrastructure that were estimated for lease sales in both the Beaufort Sea and Chukchi OCS areas. This generalized scenario is a realistic way to describe future activities because commercial-size discoveries could occur in either area or both areas. For instance, some oil/gas discoveries in the Chukchi could be uneconomic to develop, whereas smaller discoveries in the Beaufort might be commercial because they are closer to existing infrastructure and have lower development costs.

For the present EIS analysis, we take a more detailed approach and divide activities into individual sale scenarios. This is because the environmental analyses focus on unique conditions in each of the two program areas. Without accurate knowledge of the location of future offshore projects, we have simply divided the total oil/gas production into equal parts. For the Chukchi, development will start with the discovery and development of the first large field that could serve as the anchor for subsequent offshore development. There is existing oil/gas infrastructure onshore adjacent to the Beaufort OCS, so we divide the activities into two "typical sales." This procedure does not imply that we expect the activities from each sale to be exactly the same. Some sales could result in more activity and other sales could result in less activity. But the total new offshore infrastructure for the Beaufort OCS estimated for environmental impact analysis is the sum of two typical sales. The scenario analyzed in this EIS is summarized in Table B-2, where the total oil (or equivalent gas) development amounts to 2 Bbbl (12 Tcf) produced from up to 7 new offshore fields.

Because of this revised model for sale-specific analysis, there are differences between the estimates in our previous programmatic analysis (Table B-1) and present EIS (Table B-2). The largest difference is for exploration drilling. The sale-specific scenarios estimate up to 7 commercial developments in the two OCS areas, and these new fields must be defined by drilling. The total of exploration (wet and dry) and delineation wells for the sale-specific scenarios is 54 wells, whereas the programmatic EIS listed "up to 30" exploration wells. A change in analytical format (Arctic OCS to sale-specific) results in a necessary increase in exploration drilling operations. The main effect is that temporary disturbances will occur at more sites and there would be an increase in drilling waste discharges offshore.

**Scenario for the "Typical" Beaufort Lease Sale (Sales 209 and 217).** To account for the uncertainties of the scenarios, we can bracket both a "low case" and a "high case", although environmental analysis will focus on the high case to provide a conservative approach. The "low case" is defined as 1 field with 125 MMbbl of oil production. A plausible schedule for exploration and development activities associated with the low-case is given in Table B-3. The high-case includes three new fields with a combined production of 500 MMbbl (Table B-4). Converting these oil volumes to gas,

this would be 750 billion cubic feet (Bcf) (low case) to 3,000 Bcf (high case). The low case is likely to represent associated gas in oil fields, while the high case could represent one or more large gas fields. We assume that the sequence of events for the first "typical sale" (Sale 209, scheduled for 2009) would be repeated 2 years later after the second sale (Sale 217, scheduled for 2011). However, this does not imply that identical activities will occur as a result of each sale, only that these general assumptions are reasonable for purposes of environmental impact analysis. As a result of exploration following these two sales, we assume that up to six fields of ranging in size from 125-500 MMbbl will be discovered and developed, eventually producing up to 1.0 Bbbl of oil (or 6 Tcf of gas). These estimates assume that there will be no long delays associated with regulatory or legal actions affecting the exploration efforts by industry.

**Exploration Activities.** Seismic surveys for exploration could begin prior to the sale and continue each year through the primary lease term (10 years). These surveys are needed to identify prospective blocks for bidding in lease sales and to optimize drilling sites on leases acquired in sales. Seismic surveys are likely to be more frequent during the earlier phase of exploration, and later surveys could be less frequent (see Table B-4). Survey operations could be conducted during each calendar year, with individual surveys focusing on a different prospect or area.

Exploration drilling is assumed to begin in the year after the sale and continue at a rate of 1-4 wells per year, which includes dry wells, discovery wells, and delineation wells. Drilling operations are expected to take between 30-90 days at each well site, depending on the depth to the target formation, downhole difficulties during drilling, and logging/testing operations. This drilling timeframe does not include unexpected regulatory or legal delays. The number of wells resulting from a "typical sale" would range from 8-22 wells (low case; high case). The implied success rate for exploration drilling is 25-33% (1 discovery in 4 wells for the low case; 3 discoveries in 9 wells for the high case). After a discovery is made, delineation wells will use the same drilling rig and continue over a 2-year period. While the drilling rig will most likely be located on a drill ship there is the potential that a jack-up rig could be utilized. If exploration results in only dry wells, the minimum number of future wells is estimated to range from 3-6 wells (31 wells have already been drilled on the Beaufort OCS). As a result of both lease sales (Sales 209 and 217), we estimate that up to 30 more wells could be drilled to discover and delineate as many as six new fields.

Artificial ice islands grounded on the seabed could be constructed as temporary drilling platforms in shallow-water sites (up to 10 m [33 ft]) and winter drilling operations will be supported by ice roads over the landfast ice. It is unlikely that gravel islands will be constructed to drill exploration wells, because they would be prohibitively expensive. Mobile, bottom-founded platforms (set on the seafloor) could be used to drill exploration wells in water depths of 10-20 m (33-66 ft) during winter or summer months. During the summer season (July-Oct.) drillships could be used to drill prospects in water depths of 20 m or more, and these operations will be supported by icebreakers and supply boats. All drilling activities will use helicopters to fly crew and light supplies to the offshore vessels and platforms. If a jack-up rig is utilized it would require that same support as a drill ship and could be in place from July through October of any year in which it was used.

**Discharges from Exploration Wells.** Geologic mapping indicates that the prospects likely to be drilled have reservoir depths ranging from 3,000-15,000 ft in the subsurface. For purposes of analysis, we assume that the typical exploration well would be 10,000 ft. We assume that authorized waste discharges from exploration drilling operations will be 100% of the rock cuttings and 20% of the drilling mud (80% of the drilling mud is reconditioned). For a typical 10,000-ft exploration well, the on-site discharges would be 125 tons of mud per well (625 tons total with 20% waste) and 825 tons of rock

cuttings. These estimates are in dry weight with 1 ton = 2,000 pounds. The total discharges for all estimated exploration and delineation wells are given in Table B-2.

**Development Activities.** For a "typical sale" in the Beaufort, we assume the discovery/development of 1-3 fields ranging in size from 125-500 MMbbl (Table B-3 and B-4). Alternately, this scenario could be represented as 750-3,000 Bcf of gas. These oil or gas fields could be located anywhere in the program area, but it is more likely that smaller fields would be located near existing infrastructure and in relatively shallow water. In some cases, the smaller fields could be developed as satellite pools drilled from existing facilities (Liberty is an example). Other small fields would require new offshore platforms. Generally, the smaller fields would have shorter subsea pipelines through shallow water. Large fields are more likely to be discovered in more remote parts of the sale area and could be in deeper water. Remote locations in the Beaufort OCS have been less explored and are more likely to hold large untested prospects. Larger area fields could use subsea wells to tap the distal portions of the pools, and subsea wells would be "tied back" to a central production platform. Large, remote fields would tend to have longer, larger diameter offshore pipelines, a new coastal facility, and new onshore pipeline segments to connect to the existing North Slope gathering system. To analyze the effects of development in different settings, we defined the high case with three pools (2 small and 1 medium size). Otherwise, assuming four small pools for a high-case analysis would imply that all of the pools are nearshore and relatively close to existing infrastructure.

Development scenarios optimistically assume that the first discovery will be made 2 years after Lease Sale 209 (in 2009). The low case scenario (Table B-3) assumes that one field will produce 125 MMbbl of oil. If there are no long delays associated with regulatory or legal actions, production could start in 2019 (10 years after the sale) and peak at approximately 45,000 bbl/day. Production could last 15 years (until 2033), and then abandonment operations would take 2 years. The high-case scenario (Table B-4) assumes that three new fields, ranging in size from 125-250 MMbbl, will be discovered between 2011 and 2015. If there are no long delays associated with regulatory or legal actions, oil production from the first field could start in 2019 (10 years after the lease sale). Production from these three hypothetical fields could peak at 152,000 bbl/day in 2025 and continue until 2038. Abandonment operations would last 2 years for each development project. The offshore fields would be developed using one production platform each, but the larger (250 MMbbl) field also could employ subsea wells to recover oil from the outer edge of the pool. Production platforms in shallow water (<15 m [50 ft]) could be artificial gravel islands, whereas platforms in water depths of 10-50 m (33-164 ft) will be bottom founded and design to withstand pack-ice conditions. For deeper water sites (>50 m), subsea wells could be tied back to the main production platform in shallower water. Using current technology it is feasible to "tie back" 3-phase oil flowlines to the main platform over distances up to approximately 20 mi. Tie-back distances for subsea gas flowlines could be up to approximately 80 mi.

Production wells include a mix of near-vertical and laterally-extended wells drilled from the platform. The average reservoir depth is assumed to be 10,000 ft, and the drilled depth of production wells is assumed to be 13,000 ft. We also assume that one-third of the total wells drilled in an oil field will be service wells (ratio of producer to injection wells is 2:1). Injection wells are used to dispose of wastes in the subsurface and for secondary and tertiary recovery strategies (pressure maintenance; reservoir sweep by fluids). Gas fields are typically developed using fewer wells because well-drainage areas are greater and fewer waster injection wells are needed. For comparison, a reservoir with oil that required 30 wells (20 oil wells plus 10 injections wells) might only require 6 wells (5 gas wells plus 1 injection well) if it was a gas pool. A typical 13,000-ft production well will use approximately 860 tons of drilling mud and produce approximately 1,200 tons of rock cuttings. We assume that 80% of the drilling mud will be recycled during the multiple-well program, so 172 tons per well will be waste product. Spent drilling mud, rock cuttings, and formation water will be treated and then disposed of in the subsurface through

injection wells. In some cases, drilling wastes could be transported off-site to facilities for treatment and subsurface disposal.

The route selection and installation of offshore pipelines will take 1-2 years and could occur either in the summer open-water season or during winter when the landfast ice has stabilized. New onshore pipeline sections will take 1 year to complete with construction activities taking place simultaneously with the offshore pipeline installation. We assume that offshore pipelines will be trenched as a protective measure against damage by ice in all water depths <50 m (164 ft). At the coastal landfall, pipelines will be protected from shoreline erosion. Onshore oil pipelines will be elevated at least 2 m on vertical support members (VSM). Onshore gas pipelines will often be buried because they are more efficient to operate when chilled.

Because there is existing infrastructure on the North Slope, new offshore projects will use processing facilities and pipeline systems wherever possible. New onshore pipelines will be required to reach the existing gathering system. Oil pump stations (or gas compression stations) at the landfall are needed to control pressure in the onshore pipeline segments. Depending on the location of the field, a new landfall could be constructed near Cape Simpson for projects in the western Beaufort with likely overland pipeline corridors south of Teshekpuk Lake through NPR-A to the Kuparuk field. For projects in the central Beaufort, the facilities at Milne Point, Northstar, or Endicott could be modified to handle new offshore production. For developments in the eastern Beaufort a new onshore facility in the Point Thomson area would be needed to handle oil or gas production from offshore fields. Onshore pipeline sections will take 2-4 years to complete, with construction activities taking place simultaneously with the offshore pipeline installation. For onshore pipelines, typically both oil and gas pipelines would be elevated on supports, but large-diameter gas pipelines would be buried in the same corridor.

**Production Activities.** The total lifecycle (exploration through production activities) is estimated to be approximately 30-40 years, assuming an accelerated pace of discovery and development. Considering the typical field sizes assumed in the scenario, oil production could last 15-20 years (see Table B-3 and B-4). Field life could be extended if the platform and wells are used for gas production after oil reserves are depleted. Later gas production is contingent on the construction of a gas transportation system from the North Slope and would require the installation of gas-gathering lines connected to the future export system. Given the current realities about a major gas project and the abundant proven gas resources near Prudhoe Bay, we do not expect significant gas sales from projects on the Beaufort OCS until after 2018.

Once an offshore project is constructed, operations largely involve resupply of materials and personnel, inspection of various systems, and maintenance and repair. Little maintenance and repair work is expected on the platform itself, but it is likely that processing equipment might be upgraded to remove bottlenecks in production systems. Well workovers will be made at intervals of 5-10 years to restore flow rates in production wells. Pipelines will be inspected and cleaned regularly by internal devices (pigs). Crew changes usually are at weekly intervals.

**Transportation Activities.** Operations at remote locations in the Beaufort Sea would require transportation of materials, supplies, and personnel by different means, depending on seasonal constraints and phase of the operations. The general assumptions discussed in this section can be integrated with the scenario schedule shown in Tables B-3 and B-4 to visualize the full extent of transportation activities. During exploration seismic surveys, the vessels are largely self contained, so there would be a minimum amount of helicopter flights (assume 1 per day) to transport personnel, seismic data, and light supplies. As previously discussed, seismic operations would be about 30 days in the summer open-water season (see Tables B-3 and B-4 for the number of estimated annual seismic surveys). We assume that the

smaller support vessel would make occasional trips (1 once every 2 weeks) to refuel and resupply (probably at West Dock).

During exploration drilling, operations would be supported by both helicopters and supply vessels. Helicopters probably would fly from Prudhoe-area base camps at a frequency of one to three flights per day. Support vessel traffic would be one to three trips per week, also out of the Prudhoe area.

To support operations in remote parts of the Beaufort OCS, new shorebases might be needed. Onshore site surveys and construction would begin after a commercial discovery is made. Heavy equipment and materials would be moved to the coastal site using barges, aircraft, and perhaps using winter ice roads. Transportation activities would be more frequent during the construction phase, beginning about 3 years after the discovery is made and will take another 3 years for completion of the new facility. During this construction phase, there could be one to two barge trips (probably from either West Dock) in the summer open-water season. Aircraft (C-130 Hercules or larger) trips could be up to five per day during peak periods. The overall level of transportation in and out of the shore base would drop significantly after construction is completed for both the shore base and offshore platform. During production operations, aircraft generally would be smaller with less frequent flights (2 per day). Ice-road traffic would be intermittent during the winter months.

Offshore construction (platform and pipeline installation) and development drilling operations would be supported by both helicopters and supply vessels from the new shore base. Helicopters probably would fly from the Prudhoe area or the new shore base(s) at a frequency of one to three flights per day during development operations. Support-vessel traffic would be one to three trips per week from either West Dock or the new shore base. During normal production operations the frequency of helicopter flights offshore would remain the same (1-3 per day), but marine traffic would drop to about one trip every 1-2 weeks to the production platform. Marine traffic would occur during the open-water season and possibly during periods of broken ice with ice-reinforced vessels. Assuming that barges will be used to transport drilling cutting and spent mud from subsea wells to an onshore disposal facility, we estimate one barge trip per subsea template (4 wells). This means that there could be two barge trips (during summer) to the new onshore facility over a period of 6 years.

Produced oil and gas will be transported by subsea pipelines buried in trenches to existing gathering lines. Oil gathering lines are connected to Pump Station #1 of TAPS. Oil production would be carried by TAPS across Alaska to the port of Valdez, where it will be loaded on double-hull tankers bound primarily for U.S. West Coast markets. Gas-gathering lines would be connected to a gas treatment facility and then transported by a new overland pipeline (buried most of its route) across Alaska, through Canada, and eventually to U.S. markets.

**Decommissioning.** The end of economic life for a field happens when the income from production does not cover the costs of operations. Commonly, the economic limit is reached before all of the oil or gas in a pool is recovered. Typically, only 20-50% of the original oil in place is recovered (Prudhoe Bay is an exception that will recover over 60%). A typical gas field will yield approximately 60-90% of the original gas in-place. When the economic limit is reached, procedures to shut down the facility will start.

**Activities for Chukchi Lease Sales (Sales 212 and 221).** The scenario is more speculative for future Chukchi lease sales because this area is very remote and little exploration has occurred to-date. Activities will be hampered by difficult logistics and very high costs, so future development is not as likely as in the Beaufort OCS that is adjacent to onshore infrastructure surrounding Prudhoe Bay.

Exploration activities (marine seismic programs and drilling) are called the reasonably foreseeable scenario because it is logical to assume that companies who buy leases will attempt to explore them.

Industry interest has increased recently for exploration in the Chukchi, partly prompted by high oil and gas prices and advancements in various engineering technologies that could help overcome the difficult conditions in this area. The MMS' 2006 petroleum assessment indicates that the mean conventionally recoverable oil resource is 15.38 Bbbl with a 5% chance of 40.08 Bbbl (USDOI, MMS, 2006e). The mean undiscovered gas resources total 76.77 Tcf with a 5% chance of 209.53 Tcf. Most government and industry experts agree that this province could hold large oil and gas fields comparable to any frontier area in the world. Although there are exploration opportunities that could lead to commercial development, the onset of oil and gas production is not expected for at least a decade.

Because no infrastructure exists near this remote sale area, the Chukchi scenario includes the discovery and first commercial development of only the first offshore field. Under current conditions, a 1-Bbbl oil field would be the minimum expected size of the first stand-alone commercial project. Alternatively, this scenario could include development of a large, 6-Tcf gas field. After this "anchor field" is discovered and developed, it would provide the infrastructure to support subsequent developments. We assume that this first field will solve most of the engineering and regulatory hurdles in this frontier area (see Table B-2), so no development in the Chukchi OCS is expected until the anchor field is developed. The impacts associated with this 1-Bbbl field were analyzed in the Sale 193 EIS (USDOI, MMS, 2007d) and we repeat this analysis in the present EIS because the anchor field has not been discovered yet. An estimated schedule of activities associated with the discovery and development of this first anchor field is given in Table B-6. In contrast to the Chukchi Sea, likely prospect locations in the Beaufort Sea are closer to shore and existing infrastructure, so a large offshore anchor field is not required. The anchor field for the North Slope is the Prudhoe Bay field which started oil production through TAPS in 1977.

Natural gas discoveries could be developed when a transportation system is constructed and has available capacity for new gas supplies from the Chukchi. At the present time, there is no gas-export system from northern Alaska and none is expected until 2018 at the earliest. Several gas transportation projects have seemed imminent over the years, but none of them entered the construction phase. Gas production from the Chukchi would be prohibitively expensive unless several large gas fields were discovered to support the cost of a new overland gas pipeline across NPRA to the Prudhoe Bay area (250 miles away). Without transportation systems to carry gas to market, associated gas recovered with oil production will be used a fuel for facilities and reinjected. This means that even if a gas pipeline is connected to outside markets, associated gas in oil fields would not be available for export until the oil fields are depleted. Oil production from the Chukchi is assumed to cross NPRA as an elevated pipeline connected to the existing TAPS pipeline, with tankers routes to U.S. West Coast markets. A high-pressure gas pipeline is assumed to cross NPRA where it would be chilled and buried in the same corridor.

**Exploration Activities.** Seismic surveys for exploration are likely to begin before a scheduled lease sale and could continue each year through the primary lease term (10 years). This work is needed to identify prospective blocks for bidding in lease sales and to optimize drilling sites on tracts acquired in lease sales. Seismic surveys will involve both 2D and 3D survey methods. Approximately 80,000 line-miles of 2D seismic data were collected in the Chukchi OCS between 1970 and 1990, and subsequent seismic surveys (2006 and later) are likely to be 3D surveys. Future marine seismic surveys could occur during the summer (July-Nov.). Seismic surveys are likely to be more frequent in the early years following a lease sale and then taper off through the later part of the 10-years primary lease term (see Table B-7). Survey operations could be conducted during each calendar year, with individual surveys focusing on different prospects or areas. Marine surveys may be split into two phases, one starting early

in the summer (July) in the Chukchi and then moving into the Beaufort, then finishing in the late season (Nov.) back in the Chukchi. This flexible strategy would, in some years, be more efficient to accommodate changing ice conditions in the survey areas. Seismic surveys in the Beaufort OCS might be coordinated with surveys in the Chukchi OCS and could employ the same vessels. Additional details about seismic survey equipment and methods are given in the seismic-survey programmatic EIS (MMS, 2006a).

With better resolution of the subsurface structure using 3D seismic data, well locations will be proposed. Prior to drilling exploration wells, site-clearance surveys will examine the area for geologic hazards, archeological features, and biological populations. High-resolution geophysical surveys and ancillary studies required for permits to drill will be conducted during the open-water season.

Exploration drilling is assumed to begin in the year after a lease sale and continue at an average rate of one to two wells per year (see Table B-6) completed by one drilling rig during the summer open-water season (July-Nov.). Some years could experience higher activity levels (2-4 wells by 2 independent drilling rigs) when the scenarios for all three sales (Sale 193, 212 and Sale 221) overlap. Drilling operations are expected to be 30-90 days at each well site, depending on the depth to the target formation, downhole difficulties during drilling, and logging/testing operations. This drilling timeframe does not include unexpected regulatory or legal delays. Four exploration wells may be needed to define the first commercial discovery (1 discovery well and 3 dry wells) for an implied success rate of 25%. This success rate is optimistic because the prospects are very large and some of them have been drilled previously with 5 wells in the Chukchi sale area. After a discovery is made, delineation wells will use the same drilling rig and continue over the next several years. If exploration results in only dry (failed test) wells, the minimum number of future wells would be 4 wells. The total of all exploration and delineation wells is 10 wells (Table B-2).

Considering water depth and the remoteness of this area, drilling operations are likely to employ drillships with icebreaker support vessels. Water depths greater than 100 ft and possible pack-ice incursions during the open-water season will preclude the use of bottom-founded drilling platforms. Using drillships allows the operator to temporarily move off the drill site, if sea or ice conditions require it, and the suspended well is controlled by so-called blowout-prevention equipment installed on wellheads on the seabed. These operations will be supported by icebreakers and supply boats. All drilling activities will use helicopters to fly crew and light supplies to the offshore vessels and platforms.

**Discharges from Exploration Wells.** The following discussion is the same as provided above for exploration drilling in the Beaufort Sea. Geologic mapping indicates that the prospects likely to be drilled have reservoir depths ranging from 3,000-15,000 ft in the subsurface. For purposes of analysis, we assume that the typical exploration well would be 10,000 ft. We assume that authorized onsite waste discharges from drilling operations will be 100% of the rock cuttings and 20% of the drilling mud (80% of the drilling mud is reconditioned/reused). For a typical 10,000-ft exploration well, the on-site discharges would be 125 tones of mud per well (625 tons total with 20% waste) and 825 tons of rock cuttings. These estimates are in dry weight with 1 ton = 2000 pounds. The total discharges for 10 estimated exploration and delineation wells are given in Table B-2.

Different types of drilling mud could be used in well operations, and each could have a different composition. The type of drilling mud used depends on its availability, the geologic conditions, and the preferences of the drilling contractor. Several different types of drilling mud are commonly used to drill a well, and most (80%) of these fluids are reconditioned and reused to drill subsequent wells. We assume that the drilling mud that is discharged as a waste product (20% of the total) will be a water-based mud of the generic composition shown below. All of the expensive synthetic drilling fluids are assumed to be

reconditioned and not discharged. In any case, all fluid discharges are regulated by several Federal and State agencies so as not to have adverse environmental consequences.

**Development Activities.** When a large oil or gas discovery is made and defined by delineation wells, several project designs will be considered as alternatives. Because we have no knowledge of the site-specific conditions, we can offer only a general description of a possible future project and a hypothetical timeline for development.

Water depth and sea conditions are the two main factors in selecting a platform type. Because the continental shelf is relatively deep in the Chukchi (mostly deeper than 100 ft) and affected by ice movements most of the year, a large bottom-founded platform is likely be selected as a central facility. The platform would hold one to two drilling rigs, production and service (injection) wells, processing equipment, fuel- and production-storage capacity, and quarters for personnel. Although bottom-founded platforms have been used in high-latitude settings worldwide, no platform has operated in environmental conditions equivalent to the Chukchi shelf. Conceptual designs have been proposed that are typically circular in cross-section with wide bases and constructed out of steel or concrete. The platform could be constructed in several component sections, which would be transported to the site and then mated together. The seafloor is expected to be relatively firm, so a prepared berm may not be required. The platform base is pinned to the seafloor and stabilized by its wide base, anchoring system, and ballast in cavities in the concrete structure to resist ice forces.

Because of limited topside space on the platform and widespread area of subsurface reservoir, up to half of the total production wells could be subsea wells. Subsea wells would be completed in templates (4 per template) and production would be gathered to the central platform by flowlines. Subsea well templates would be located within about 20 miles from the central platform. Pending the information collected by site-specific surveys, the subsea equipment and pipelines could be installed below the seafloor surface for protection against possible deep-keeled ice masses. Drilling on the platform would occur year-round, while subsea wells would be drilled by drillships during the summer open-water season.

A 3-phase production slurry (oil, gas, water) will be gathered to the central platform where gas and produced water will be separated and reinjected into the subsurface. Gas production also will be gathered to the central platform for treatment. Associated and solution gas recovered with oil production will be used as fuel for the facility or reinjected into the main reservoir to increase oil recovery. Subsea technology has advanced to where separation could be made by equipment on the seabed, so dual flowlines could include oil/gas mixture and produced water. This strategy would minimize problems with in-line hydrates, leak detection, and processing bottlenecks on the central platform. Shallow disposal wells will handle wastewater and treated well cuttings for on-platform wells. Drilling cuttings and mud wastes from subsea wells could be barged to an onshore treatment and disposal facility.

Installation of subsea pipelines will occur during summer open-water seasons and operations would occur during the same timeframe as the platform construction and installation. The subsea pipelines will be different sizes depending on production rates, distances, and the general development strategy. Flowlines from subsea well templates to a host platform are assumed to be 10 inches or smaller in diameter, carry up to 45,000 bbl/ day and be 20 miles long. Gathering lines from satellite platforms could be 12-18 inches in diameter, carry up to 150,000 bbl/day and be 50 miles long. The main oil pipeline to the landfall could be at least 20 inches in diameter to handle production rates ranging up to 300,000 bbl/day. The offshore pipeline run 30-150 mi between the offshore platform and landfall and will be trenched in the seafloor as a protective measure against damage by floating ice masses. Construction of subsea gas pipelines will be very similar to oil pipelines. Gas flowlines (up to 10 inches) from subsea well templates could carry about

70 million cubic feet (MMcf) per day; gathering lines (up to 18 inches) between platforms will carry about 480 MMcf/day; the main lines (>20 inches) to shore would carry over 600 MMcf/day.

At the coast, a new facility will be constructed to support the offshore operations and will also serve as the first pump station for the overland pipeline. A likely location for the shore base would be between Icy Cape and Point Belcher, near Wainwright. The overland pipelines to the Prudhoe Bay area (TAPS and the new gas pipeline), or a nearer gathering point will require coordination by BLM and oil field operators in NPR-A. In contrast to offshore pipelines, onshore pipelines will be installed during winter months. Various oil pipeline and communication lines will be installed on vertical supports above the tundra in a corridor stretching eastward approximately 250 miles to connect to the North Slope gathering system. The chilled, high pressure gas pipeline would be buried along the same corridor. Pump (or compression) stations required along the onshore corridor are likely to be collocated with fields. The overland oil pipeline is likely to be 24-36 inches in diameter to handle flow rates greater than 300,000 bbl/day. We assume that the 48-inch TAPS pipeline will transport oil from the North Slope and double-hulled marine tankers will carry oil to markets on the West Coast. A large overland gas pipeline (perhaps carrying 1 Bcf/day) would be 24-26 inches. Condensate liquids entrained in this 1 Bcf/day dense-phase pipeline could amount to 25,000 bbl/day.

An approximate timeframe for the scenarios is given in Table B-6. The time from leasing to production startup is expected to be 10-15 years. We assume that the commercial discoveries will be made within 5 years after the lease sale, because the most attractive prospects likely will be tested first. After discovery, delineation drilling and project feasibility studies several years, followed by permitting which might include a Development EIS. When the project is approved, the design, fabrication, and installation of the facilities take another 4-5 years. Offshore and onshore pipeline permitting and construction would occur simultaneously with the offshore work. Drilling of subsea wells could start before platform installation to allow a quicker ramp up of production. A new shore base would be constructed to support the first (anchor) field and then serve as the pipeline landfall.

**Production Activities.** The lifecycle for production depends on the size of the field and development strategies, but for a typical large oil field production would last 25 years. When the oil resources are depleted, the platform and wells could be used for gas production if a gas export system is built from the North Slope. This could extend field life another 20 years. However, the earliest that a gas-export pipeline could be operational is expected to be 2018, and at least 10 years of gas reserves are readily available using existing infrastructure on the North Slope. This means that gas production from the Chukchi is may not reach market by pipeline before 2028.

Once the offshore project is constructed, operations largely involve resupply of materials and personnel, inspection of various systems, and maintenance and repair. Little maintenance and repair work is expected on the platform itself, but it is likely that processing equipment might be upgraded to remove bottlenecks in production systems. Well workovers will be made at intervals of 5-10 years to restore flow rates in production wells. Pipelines will be inspected and cleaned regularly by internal devices (pigs). Crew changes are usually at weekly intervals.

**Transportation Activities.** Operations at remote locations in the Chukchi lease sale area would require transportation of materials, supplies, and personnel by different means, depending on seasonal constraints and phase of the operations. The general assumptions discussed in this section can be integrated with the scenario schedules provided to determine the full extent of transportation activities.

During exploration seismic surveys, the vessels are largely self-contained, so there would be a minimum amount of helicopter flights (assume 1 per day) to transport personnel, seismic data, and light supplies.

As previously discussed, seismic operations would be about 30 days in the summer open-water season. We assume that the smaller support vessel would make occasional trips (1 once every 2 weeks) to refuel and re-supply from several possible locations (Kotzebue, Barrow, or West Dock).

During exploration drilling, operations would be supported by both helicopters and supply vessels. Helicopters probably would fly from Barrow at a frequency of one to three flights per day. Support-vessel traffic would be one to three trips per week, also out of Barrow.

Construction of a new shore base would begin after a commercial discovery is made. Heavy equipment and materials would be moved to the site of a new shore base near Wainwright using barges, aircraft, and perhaps winter ice roads. When the shore base is operational, both helicopter and marine vessel traffic would be out of either Barrow or the new shore base. Transportation activities would be more frequent during the construction phase, beginning about 3 years after the discovery is made, and will take another 3 years for completion of the new facility. During this construction phase, there could be one to two barge trips (probably from either West Dock or Nome) in the summer open-water season. Aircraft (C-130 Hercules or larger) trips could be up to five per day during peak periods. The overall level of transportation in and out of the shore base would drop significantly after construction is completed for both the shore base and offshore platform. During production operations aircraft generally would be smaller with less frequent flights (2 per day). Ice-road traffic would be intermittent during the winter months.

Offshore construction (platform and pipeline installation) and development drilling operations would be supported by both helicopters and supply vessels from the new shore base. Helicopters probably would fly from either Barrow or the new shore base at a frequency of one to three flights per day during development operations. Support-vessel traffic would be one to three trips per week from either Barrow of the new shore base. During normal production operations the frequency of helicopter flights offshore would remain the same (1-3 per day) but and marine traffic would drop to about one trip every 1-2 weeks to the production platform. Marine traffic would occur during the open-water season (July-Nov.) and possibly during periods of broken ice with icebreaker support vessels. Assuming that barges will be used to transport drilling cutting and spent mud from subsea wells to an onshore disposal facility, we estimate one barge trip per subsea template (4 wells). This means that there could be two barge trips per year during summer to the new onshore facility over a period of 6 years for each development requiring subsea wells.

**Decommissioning.** The end of the economic life of a field happens when income from production does not cover operating and transportation expenses. In a typical situation, wells will be permanently plugged (with cement) and wellhead equipment removed. Processing modules will be moved off the platform. Pipelines will be decommissioned, which involves cleaning the pipeline, plugging both ends, and leaving it in place, buried in the seabed. The overland pipeline is likely to be used by other oil fields in NPR-A, so it will remain in operation. Lastly, the platform will be disassembled and removed from the area, and the seafloor site will be restored to some practicable, predevelopment condition. Environmental studies will continue to evaluate the site during and after restoration. The abandonment process could take several years, with studies continuing for longer. The overall life cycle from leasing through abandonment of all fields in our scenario is expected to be <50 years.

Other options are possible. After the oil reservoir is depleted, the platform could be converted to a gas-production facility to recover the gas that was reinjected during oil production. This scenario will not occur unless a gas export system is constructed. Conversion of the offshore platform to a gas production facility could delay permanent abandonment for several more decades. Another option is that the platform and pipeline systems could serve as a hub for younger satellite fields in the surrounding area. As

a third option, the platform and partially dismantled topside facilities could be used for civilian or military purposes. For each option, abandonment activities would be delayed for decades. Considering the cost of installing this infrastructure (multi-billion dollars), it is unlikely that complete abandonment would be a cost-effective alternative.

### Reductions in the Scenario for Deferral Areas.

Deferring an area eliminates the possibility that commercial development will occur and also eliminates the associated impacts from development in the deferral area. The following discussion describes how the development scenario is modified to account for portions of the program area not included in lease sales.

Petroleum exploration in a frontier area can be characterized by a simple concept: area equals opportunity**.** More area open to leasing usually translates into more exploration activities, and more exploration often translates to more development. However, it is impossible to accurately predict where future commercial fields will be located because they have not been discovered. Because oil and gas pools are not uniformly distributed in nature, only a few pools could contain all of the economically recoverable reserves in the sale area. The remainder of the area could either lack the necessary geology to produce commercially viable fields or have environmental conditions that would preclude development. Deferrals affecting small portions of the sale area could make industry to shift their interest to the parts that are still open to leasing. Excluding large areas or very prospective parts of the sale area could discourage leasing and exploration altogether.

Removing areas from lease sales (deferrals), to varying extent, would reduce the potential to make discoveries that could lead to commercial production. There is no precise way to determine the reductions associated with deferral areas, but one general way is to reduce the commercial potential proportionally to the area off-limits to leasing. For example, if a deferral involves 20% of the sale area, the assumed production volume of 1 Bbbl could be reduced by 200 MMbbl. However, this approach misrepresents the situation because we are not excluding portions of known commercial fields in a deferral area, and sub-commercial fields will not be developed anyway. Commercially viable fields will be discovered and developed, or they will not. A probabilistic approach is more realistic because it defines the chance that commercial development will occur. In other words, if a deferral area contains 20% of the overall resource potential in a sale area, then eliminating that deferral from leasing will mean a 20% lower chance that commercial production would occur somewhere in the sale area. While the two procedures to estimate reductions for deferral areas appear to be the same, the implications are very different. If the only commercial field occurs in the deferral area, then 100% of the recoverable oil or gas is lost—not just 20% of the total in the sale area. Using probabilities to describe the reduction in commercial potential is more realistic than using volumes because often the deferral volumes are too small to be commercial projects.

The probabilistic values associated with the deferral areas are called the *Commercial Resource Potential.* The commercial resource potential is calculated using data from the current petroleum assessment for these areas (USDOI, MMS, 2006e). Economically recoverable oil and gas resources for each geologic play scaled according to the fraction of the play area contained in the deferral. The fractional allocations for all plays are summed into the potential remaining in the sale area. The difference between the total potential (the entire sale area) and the potential lost in the deferral area is the remaining commercial resource potential. The commercial resource potential for the Beaufort Sea deferral alternatives is listed in Table B-5. The commercial resource potential estimated for the Chukchi Sea deferral alternatives is listed in Table B-7.

From this analysis, the decrease in commercial resource potential associated with each deferral alternatives ranges from 1-5% of the total potential for the proposed action. Removal of all of the deferral areas in the Beaufort would decrease the potential for commercial development by 12%.

**Table B-1 Exploration and Development Scenarios in the 2007-2012 Programmatic EIS**

| Scenario Elements | Arctic Subregion<br>Beaufort Sea<br>Chukchi Sea | Bering Sea Subregion<br>North Aleutian Basin | South Alaska Subregion<br>Cook Inlet |
|---|---|---|---|
| Number of Sales | 5 | 2[a] | 2[b] |
| Years of Activity | 40 | 40 | 40 |
| Oil (Bbbl) | 0.5-2.0 | 0.1-0.2 | 0.1-0.2 |
| Gas (tcf) | None | 5 | 0.1-0.2 |
| Platforms | 3-10 | 4-6 | 1-2 |
| Exploration and Delineation Wells | Up to 30 | Up to 20 | Up to 10 |
| Development and Production Wells | 100-400 | Up to 200 | Up to 100 |
| Miles of New Offshore Pipelines | Up to 200 | Up to 150 | Up to 125 |
| Miles of New Onshore Pipelines | Up to 400 | Up to 50 | Up to 75 |
| Vessel Trips/Week/Platform | 1-3[c] | 1-3 | 1-3 |
| Helicopter Trips/Day/Platform | 1-3 | 1-3 | 1-3 |
| New Pipeline Landfalls | 1-3 | 1-2 | 1-2 |
| New Shore Bases | 1-2 | 1 | 0 |
| New Waste Facilities | 0-1 | 1 | 0-1 |
| New Processing Facilities | 0-1 | 1 | 0-1 |
| Docks/Causeways | 1 | 1 | 0 |
| Exploration Well Muds, Cuttings, Produced Water | 425 tons dry mud with 80% recycled; 525 tons dry rock cuttings, totaling 610 tons discharged at each well site. | 360 tons dry mud with 80% recycled; 450 tons dry rock cuttings; totaling 522 tons per site. | 360 tons dry mud, with 80% recycled; 450 tons dry rock cuttings; totaling 522 tons per site. |
| Development Wells Muds, Cuttings, Produced Water | All muds, cuttings, and produced water treated and disposed of in wells. | All muds, cuttings, and produced water discharged down hole. | All muds, cuttings, and produced water discharged down hole. |

[a]Sales in the North Aleutian Basin required that the existing presidential withdrawal was lifted prior to the sales.
[b]Lease sales in the Cook Inlet Planning Area will be special-interest sales, meaning that a sale will not occur unless industry expresses interest in response to the Call for Information.
[c]In the Arctic Subregion, service-vessel trips will occur only during open-water and broken-ice conditions.

**Table B-2: Sale-Specific Scenarios for the Arctic Multiple-Sale Lease Program.**

| | Chukchi Planning Area | Beaufort Planning Area | |
|---|---|---|---|
| | Sale 193, 212, 221 | Sale 209 | Sale 217 |
| Possible sale date | 2/08 | 3/09 | 3/11 |
| Oil and gas production (B-boe) | 1.0 | 0.5 | 0.5 |
| Fields | 1 | 3 | 3 |
| Dry exploration wells | 3 | 6 | 6 |
| Discovery wells | 1 | 3 | 3 |
| Delineation wells | 6 | 13 | 13 |
| Platforms | 1 | 3 | 3 |
| On-platform production wells | 80 | 74 | 74 |
| Injection wells | 28 | 14 | 14 |
| Subsea wells | 48 | 12 | 12 |
| Offshore pipeline (miles) | 120 | 90 | 90 |
| Onshore pipeline (miles) | 250 | Up to 70 | Up to 70 |
| New landfalls | 1 | 1 | 1 |
| New shore bases | 1 | 1 | 0 |
| Drilling mud discharge (dry tons) | 1250 | 2750 | 2750 |
| Rock cuttings discharge (dry tons) | 8250 | 18,150 | 18,150 |

Notes for Table B-2
- Scheduling for activities in Chukchi is listed in Table B-6.
- Scheduling for activities in Beaufort is listed in Table B-4 (high case).
- Production is given in units of barrels of oil equivalent, where 1 barrel of oil is equivalent to 6 thousand cubic feet of gas (1 Bbbl = 6 Tcf).
- Fields could involve one or more pools produced through a common facility.
- Dry exploration wells do not find oil or gas in commercially viable quantities.
- Discovery wells found commercial-size pools of oil or gas.
- Production wells are on offshore platforms and recover oil or gas.
- Injection wells are drilled from platforms and put gas, water or waste back into the subsurface.
- Subsea wells are tied back to the host platform with flowlines.
- Offshore pipelines are flowlines (<10”dia) from subsea wells, gathering lines between platforms (>10”), and main lines to shore (>20”).
- Onshore pipelines are overland oil lines (>24”) to the Prudhoe Bay area (TAPS).
- Offshore waste discharges are for exploration and delineation wells only. Production, injection and subsea well drilling wastes are disposed of off-site. We assume that typical exploration wells are drilled to an average subsurface depth of 10,000 ft. The typical well will use 625 tons (dry weight) of drilling mud, with 80% reconditioned/recycled, resulting in total onsite discharge of 125 tons per well. The typical well will produce 825 tons (dry weight) of rock cuttings, all of which is discharged at the offshore exploration site.

## Table B-3: Beaufort Development Scenario for 125 MMbbl (1 nearshore field)

| | Reasonably Foreseeable Exploration Sceanio | | | | | Speculative Development Scenario | | | | | | | | | | | | | Cumulative |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Exploration Seismic Surveys | Dry exploration wells | Discovery wells | Delineation Wells | Exploration Drilling Rigs | Production Platforms | Platform Wells | Platform Oil Wells | Injection Wells | Platform Drilling Rigs | Mobile Drilling Rigs | Subsea Wells | Flowlines (mi) | Offshore Pipeline (mi) | Onshore Pipelines (mi) | New Shorebases | Oil Production (MMbpy) | Oil Production (Mbpd) | Oil Production (MMb) |
| 2007 | 1 | | | | | | | | | | | | | | | | | | |
| 2008 | 3 | | | | | | | | | | | | | | | | | | |
| **2009** | 3 | | | | | | | | | | | | | | | | | | |
| 2010 | 3 | 1 | | | 1 | | | | | | | | | | | | | | |
| 2011 | 3 | | 1 | 2 | 1 | | | | | | | | | | | | | | |
| 2012 | 2 | | | 2 | 1 | | | | | | | | | | | | | | |
| 2013 | 2 | 1 | | | 1 | | | | | | | | | | | | | | |
| 2014 | 1 | 1 | | | 1 | | | | | | | | | | | | | | |
| 2015 | 1 | | | | | | | | | | | | | | | | | | |
| 2016 | 1 | | | | | | | | | | | | | | | | | | |
| 2017 | | | | | | | | | | | | | | 10 | 10 | | | | |
| 2018 | | | | | | | | | | | | | | 5 | | | | | |
| 2019 | | | | | | 1 | 6 | 6 | 0 | 1 | | | | | | | 8.8 | 24,110 | 9 |
| 2020 | | | | | | | 8 | 6 | 2 | 1 | | | | | | | 16.3 | 44,521 | 25 |
| 2021 | | | | | | | 8 | 6 | 2 | 1 | | | | | | | 16.3 | 44,521 | 41 |
| 2022 | | | | | | | | | | | | | | | | | 16.3 | 44,521 | 58 |
| 2023 | | | | | | | | | | | | | | | | | 13.4 | 36,729 | 71 |
| 2024 | | | | | | | | | | | | | | | | | 11.1 | 30,302 | 82 |
| 2025 | | | | | | | | | | | | | | | | | 9.1 | 24,999 | 91 |
| 2026 | | | | | | | | | | | | | | | | | 7.5 | 20,624 | 99 |
| 2027 | | | | | | | | | | | | | | | | | 6.2 | 17,015 | 105 |
| 2028 | | | | | | | | | | | | | | | | | 5.1 | 14,037 | 110 |
| 2029 | | | | | | | | | | | | | | | | | 4.2 | 11,581 | 114 |
| 2030 | | | | | | | | | | | | | | | | | 3.5 | 9,554 | 118 |
| 2031 | | | | | | | | | | | | | | | | | 2.9 | 7,882 | 121 |
| 2032 | | | | | | | | | | | | | | | | | 2.5 | 6,849 | 123 |
| 2033 | | | | | | | | | | | | | | | | | 2.1 | 5,753 | 125 |
| 2034 | | | | | | | | | | | | | | | | | | | |
| 2035 | | | | | | | | | | | | | | | | | | | |
| 2036 | | | | | | | | | | | | | | | | | | | |
| 2037 | | | | | | | | | | | | | | | | | | | |
| 2038 | | | | | | | | | | | | | | | | | | | |
| 2039 | | | | | | | | | | | | | | | | | | | |
| 2040 | | | | | | | | | | | | | | | | | | | |
| 2041 | | | | | | | | | | | | | | | | | | | |
| 2042 | | | | | | | | | | | | | | | | | | | |
| 2043 | | | | | | | | | | | | | | | | | | | |
| 2044 | | | | | | | | | | | | | | | | | | | |
| 2045 | | | | | | | | | | | | | | | | | | | |
| | 20 | 3 | 1 | 4 | | 1 | 22 | 18 | 4 | | | 0 | 0 | 15 >10" | 10 | | 125 | | |

Notes:
Platform wells include oil wells and injection wells (18 oil + 4 injection = 22 total)
Well recovery is 125/18 = 6.9 MMbbl per well
Some number of production wells are converted to injection wells.

## Table B-4: Beaufort Development Scenario for 500 MMbbl (3 fields)

| | Reasonably Foreseeable Exploration Scenario | | | | | Speculative Development Scenario | | | | | | | | | | | Field #1 | Field #2 | Field #3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Exploration Seismic Surveys | Dry exploration wells | Discovery wells | Delineation Wells | Exploration Drilling Rigs | Production Platforms | Platform Wells | Platform Oil Wells | Injection Wells | Platform Drilling Rigs | Mobile Drilling rigs | Subsea Wells | Flowlines (mi) | Offshore Pipeline (mi) | Onshore Pipelines (mi) | New Shorebases | Oil Production (MMbpy) | Oil Production (MMbpy) | Oil Production (MMbpy) | Combined Oil Production (MMbpy) | Combined Production Rate (Mbpd) | Cumulative Production (MMbbl) |
| 2007 | 1 | | | | | | | | | | | | | | | | | | | | | |
| 2008 | 3 | | | | | | | | | | | | | | | | | | | | | |
| **2009** | 3 | | | | | | | | | | | | | | | | | | | | | |
| 2010 | 3 | 1 | | | 1 | | | | | | | | | | | | | | | | | |
| 2011 | 3 | | 1 | 2 | 1 | | | | | | | | | | | | | | | | | |
| 2012 | 2 | 1 | | 2 | 2 | | | | | | | | | | | | | | | | | |
| 2013 | 2 | 1 | 1 | 2 | 2 | | | | | | | | | | | | | | | | | |
| 2014 | 1 | 1 | | 3 | 2 | | | | | | | | | | | | | | | | | |
| 2015 | 1 | | 1 | 2 | 1 | | | | | | | | | | | | | | | | | |
| 2016 | 1 | 1 | | 2 | 2 | | | | | | | | | | | | | | | | | |
| 2017 | 1 | 1 | | | 1 | | | | | | | | | | | | | | | | | |
| 2018 | | | | | | | | | | | | | | 10 | 10 | | | | | | | |
| 2019 | | | | | | 1 | 6 | 6 | 0 | 1 | | | | 5 | | | 8.8 | | | 8.8 | 23,973 | 8.8 |
| 2020 | | | | | | | 8 | 6 | 2 | 1 | | | | 10 | 10 | | 16.3 | | | 16.3 | 44,521 | 25.0 |
| 2021 | | | | | | | 8 | 6 | 2 | 1 | | | | 10 | 10 | | 16.3 | | | 16.3 | 44,521 | 41.3 |
| 2022 | | | | | | 1 | 6 | 6 | 0 | 1 | | | | 15 | 20 | | 16.3 | 13.5 | | 29.8 | 81,507 | 71.0 |
| 2023 | | | | | | | 8 | 6 | 2 | 1 | 1 | 4 | 5 | 10 | 10 | | 13.4 | 16.9 | | 30.3 | 82,962 | 101.3 |
| 2024 | | | | | | 1 | 14 | 12 | 2 | 2 | 1 | 4 | 5 | 15 | 10 | | 11.1 | 22.5 | 8.8 | 42.3 | 115,918 | 143.6 |
| 2025 | | | | | | | 16 | 12 | 4 | 2 | 1 | 4 | 5 | | | | 9.1 | 30.0 | 16.3 | 55.4 | 151,711 | 199.0 |
| 2026 | | | | | | | 8 | 6 | 2 | 1 | | | | | | | 7.5 | 30.0 | 16.3 | 53.8 | 147,336 | 252.7 |
| 2027 | | | | | | | | | | | | | | | | | 6.2 | 30.0 | 16.3 | 52.5 | 143,727 | 305.2 |
| 2028 | | | | | | | | | | | | | | | | | 5.1 | 24.0 | 13.4 | 42.5 | 116,520 | 347.7 |
| 2029 | | | | | | | | | | | | | | | | | 4.2 | 19.2 | 11.1 | 34.5 | 94,485 | 382.2 |
| 2030 | | | | | | | | | | | | | | | | | 3.5 | 15.4 | 9.1 | 28.0 | 76,635 | 410.2 |
| 2031 | | | | | | | | | | | | | | | | | 2.9 | 12.3 | 7.5 | 22.7 | 62,172 | 432.9 |
| 2032 | | | | | | | | | | | | | | | | | 2.5 | 9.8 | 6.2 | 18.5 | 50,797 | 451.4 |
| 2033 | | | | | | | | | | | | | | | | | 2.1 | 7.9 | 5.1 | 15.1 | 41,337 | 466.5 |
| 2034 | | | | | | | | | | | | | | | | | | 6.3 | 4.2 | 10.5 | 28,818 | 477.0 |
| 2035 | | | | | | | | | | | | | | | | | | 5.0 | 3.5 | 8.5 | 23,344 | 485.6 |
| 2036 | | | | | | | | | | | | | | | | | | 4.0 | 2.9 | 6.9 | 18,914 | 492.5 |
| 2037 | | | | | | | | | | | | | | | | | | 3.0 | 2.5 | 5.5 | 15,068 | 498.0 |
| 2038 | | | | | | | | | | | | | | | | | | | 2.1 | 2.1 | 5,753 | 500.1 |
| 2039 | | | | | | | | | | | | | | | | | | | | | | |
| 2040 | | | | | | | | | | | | | | | | | | | | | | |
| 2041 | | | | | | | | | | | | | | | | | | | | | | |
| 2042 | | | | | | | | | | | | | | | | | | | | | | |
| 2043 | | | | | | | | | | | | | | | | | | | | | | |
| 2044 | | | | | | | | | | | | | | | | | | | | | | |
| 2045 | | | | | | | | | | | | | | | | | | | | | | |
| 2046 | | | | | | | | | | | | | | | | | | | | | | |
| | 21 | 6 | 3 | 13 | | 3 | 74 | 60 | 14 | | | 12 | 15 | 75 | 70 | | 125 | 250 | 125 | 500 | | |

Notes:
Platform wells include oil wells and injection wells (60 oil + 14 injection = 74 total)
Well recovery includes subsea production wells (500 MMbbl from 72 wells = 6.9 MMbbl per well)
Some production wells are converted to injection wells.
Total oil wells include platform wells (60) + subsea wells (12) for a total of 72 oil wells.
Subsea wells do not include injection wells and 3-phase flowlines carry production back to the platform for separation.

**Table B-5 Commercial Resource Potential in Deferral Areas, Beaufort Sea OCS**

| Beaufort Sea OCS Deferral Alternatives | Commercial Resource Potential |
|---|---|
| Alternative 3 Barrow Subsistence | 1% |
| Alternative 4 Nuiqsut Subsistence | 5% |
| Alternative 5 Eastern Beaufort | 4% |
| Alternative 6 Deepwater | 2% |

The chance that the commercial oil and gas fields could be discovered and developed in the deferral areas is defined by the Commercial Resource Potential, where 100% of the development potential is contained in the full sale area (also referred to as the proposed action, or Alternative 2).

For example, there is a 5% chance (or 1-in-20) that commercial fields could be discovered and developed in the Nuiqsut deferral area. By removing the Alternative 4 deferral, there is a 95% chance that commercial production could occur elsewhere in the Beaufort program area.

If leasing were eliminated in all four deferral areas, the potential to discover and develop new commercial oil and gas fields in the Beaufort program area would be reduced by 12%.

This analysis reflects the current data and knowledge of MMS. Industry groups could have a different view of the petroleum potential in the Beaufort OCS. Future leasing patterns may reflect other industry views regarding the possible location of possible commercial-sized fields in the sale area.

## Table B-6: Development Scenario for Sales 193, 212 or 221 (1 Bbbl standalone field)

| | Reasonably Foreseeable Exploration Scenario | | | | | Speculative Development Scenario | | | | | | | | | | | | Cumulative |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Exploration Seismic Surveys | Dry exploration wells | Discovery wells | Delineation Wells | Exploration Drilling Rigs | Production Platforms | Platform Wells | Platform Drilling Rigs | Injection Wells | Mobile Drilling Rigs | Subsea Wells | Flowlines (mi) | Offshore Pipeline (mi) | Onshore Pipelines (mi) | New Shorebases | Oil Production (MMbpy) | Oil Production (Mbpd) | Oil Production (MMb) |
| 2005 | | | | | | | | | | | | | | | | | | |
| 2006 | 3 | | | | | | | | | | | | | | | | | |
| 2007 | 1 | | | | | | | | | | | | | | | | | |
| **2008** | 4 | | | | | | | | | | | | | | | | | |
| 2009 | 3 | 1 | | | 1 | | | | | | | | | | | | | |
| 2010 | 3 | | 1 | | 1 | | | | | | | | | | | | | |
| 2011 | 2 | | | 2 | 1 | | | | | | | | | | | | | |
| 2012 | 1 | | | 2 | 1 | | | | | | | | | | | | | |
| 2013 | 1 | | | 2 | 1 | | | | | | | | | | | | | |
| 2014 | 1 | 1 | | | 1 | | | | | | | | | | 1 | | | |
| 2015 | 1 | 1 | | | 1 | | | | | | | | | 50 | | | | |
| 2016 | 1 | | | | | | | | | | | | 30 | 75 | | | | |
| 2017 | | | | | | | | | | | | | 30 | 75 | | | | |
| 2018 | | | | | | | | | | | | | 30 | 50 | | | | |
| 2019 | | | | | | | | | | 2 | 8 | 5 | | | | | | |
| 2020 | | | | | | 1 | 6 | 1 | 3 | 2 | 8 | 5 | | | | 54.0 | 147,945 | 54 |
| 2021 | | | | | | | 18 | 2 | 5 | 2 | 8 | 5 | | | | 70.0 | 191,781 | 124 |
| 2022 | | | | | | | 18 | 2 | 5 | 2 | 8 | 5 | | | | 82.0 | 224,658 | 206 |
| 2023 | | | | | | | 18 | 2 | 5 | 2 | 8 | 5 | | | | 82.0 | 224,658 | 288 |
| 2024 | | | | | | | 10 | 2 | 6 | 2 | 8 | 5 | | | | 82.0 | 224,658 | 370 |
| 2025 | | | | | | | 10 | 2 | 4 | | | | | | | 82.0 | 224,658 | 452 |
| 2026 | | | | | | | | | | | | | | | | 72.2 | 197,808 | 524 |
| 2027 | | | | | | | | | | | | | | | | 63.5 | 173,973 | 588 |
| 2028 | | | | | | | | | | | | | | | | 55.9 | 153,151 | 644 |
| 2029 | | | | | | | | | | | | | | | | 49.2 | 134,795 | 693 |
| 2030 | | | | | | | | | | | | | | | | 43.3 | 118,630 | 736 |
| 2031 | | | | | | | | | | | | | | | | 38.1 | 104,384 | 774 |
| 2032 | | | | | | | | | | | | | | | | 33.5 | 91,781 | 808 |
| 2033 | | | | | | | | | | | | | | | | 29.5 | 80,822 | 837 |
| 2034 | | | | | | | | | | | | | | | | 26.0 | 71,233 | 863 |
| 2035 | | | | | | | | | | | | | | | | 22.8 | 62,466 | 886 |
| 2036 | | | | | | | | | | | | | | | | 20.1 | 55,068 | 906 |
| 2037 | | | | | | | | | | | | | | | | 17.7 | 48,493 | 924 |
| 2038 | | | | | | | | | | | | | | | | 15.6 | 42,740 | 939 |
| 2039 | | | | | | | | | | | | | | | | 13.7 | 37,534 | 953 |
| 2040 | | | | | | | | | | | | | | | | 12.1 | 33,151 | 965 |
| 2041 | | | | | | | | | | | | | | | | 10.6 | 29,041 | 976 |
| 2042 | | | | | | | | | | | | | | | | 9.8 | 26,849 | 986 |
| 2043 | | | | | | | | | | | | | | | | 8.2 | 22,466 | 994 |
| 2044 | | | | | | | | | | | | | | | | 6.2 | 16,986 | 1000 |
| | 21 | 3 | 1 | 6 | | 1 | 80 | | 28 | | 48 | 30 <10" | 90 >10" | 250 | | 1000 | | |

Notes:
Platform well count includes oil wells and injection wells (52 oil + 28 inj = 80)
Subsea wells are all oil production wells (no injection wells)
Platform oil wells (52) + subsea wells (48) = 100 wells (or 10 MMbbl per well)

**Table B-7 Commercial Resource Potential in Deferral Areas, Chukchi Sea OCS**

| Beaufort Sea OCS Deferral Alternatives | Commercial Resource Potential |
|---|---|
| Alternative 3 Coastal Zone | 17% |
| Alternative 4 Ledyard Bay | 7% |
| Alternative 5 Hanna Shoal | 4% |
| Alternative 6 Deepwater | 0% |

The chance that the commercial oil and gas fields could be discovered and developed in the deferral areas is defined by the Commercial Resource Potential, where 100% of the development potential is contained in the full sale area (also referred to as the proposed action, or Alternative 2).

For example, there is a 17% chance (or 1-in-6) that commercial fields could be discovered and developed in the Coastal deferral area. In contrast, it is highly unlikely that commercial discoveries and development would occur in the Deepwater deferral (Alternative 6) because of unfavorable geologic conditions, inadequate technology and prohibitive costs.

If leasing were eliminated in all deferral areas, the overall opportunity to discover new commercial oil and gas fields in the Chukchi program area would be reduced by 21% (note, Alternatives 3 and 4 partly overlap).

This analysis reflects the current data and knowledge of MMS. Industry groups could have a different view of the petroleum potential in the Beaufort OCS. Future leasing patterns may reflect other industry views regarding the possible location of possible commercial-sized fields in the sale area.

# Appendix C

# Petroleum Geology of Alaska Arctic Offshore

# Petroleum Geology of Alaska Arctic Offshore

*Draft, 30 July 08; Revised 05 Aug, K.W. Sherwood*

**Locations of Arctic Planning Areas and Assessment Provinces.**

The Beaufort Sea Planning Area extends from the 3-mile limit of State of Alaska waters northward to 75° N. latitude on the west (west of 148° W. longitude) or to 74° N. latitude (east of 148°), and from 156º W. longitude (roughly north of the village of Barrow) to the Canadian maritime boundary (Figure 1). The area of accessible petroleum potential is a subarea within the planning area and extends from the 3-mile limit of State of Alaska waters northward across the continental shelf to the 500-m (1,650-ft) isobath at the shelf edge (Figure 2). The 500 m (1,650 ft) isobath was first adopted in the 1995 MMS assessment as a reference marker approximating the present practical limit for petroleum development in the Beaufort Sea (Sherwood, 1998:Fig. 12.1). Beyond the 500-m (1,650-ft) isobath, the extreme water depths, steeply sloping seafloor, and heavy ice conditions essentially preclude exploration and development using existing technologies. This view is supported by a 2008 study (MMS, 2008) by the Canadian firm *IMV Projects Atlantic* that concludes that: "there are no known bottom-founded platform design solutions for water depths greater than 330 ft (100 m) that could be deemed workable or proven for multi-year ice areas."

The Chukchi Sea Planning Area is located offshore northwestern Alaska, as shown in Figure 1. As shown in Figure 3, the east boundary of the planning area lies along 156º W. longitude (near Point Barrow) and the 3-mile offshore limit of State of Alaska northwest coast waters. The west boundary of the planning area lies along 169° W. longitude, which demarcates the Russian waters of the Chukchi shelf. The planning area extends from 68º20′ N. latitude (near Point Hope) northward to 75º N. latitude. Water depths within the Chukchi Sea Planning Area range up to 3,800 m (12,500 ft), with the greatest depths over the Canada basin in the northeast corner of the planning area (Figure 3) (Perry and Fleming, 1987). Water depths across most of the Chukchi shelf typically are about 48 m (160 ft), except in the Barrow and Hanna submarine canyons, where water depths range from 50-200 m (165-660 ft; Figure 3).

The northern, off-shelf parts of the planning area overlie areas of the deep Canada basin and the submarine ridges of the Chukchi borderland. In prior oil and gas assessments by MMS, mostly because of physical access issues, the northern, off-shelf areas were assessed with negligible technically recoverable oil and gas resources (Sherwood, 1998:Table 12.1). A recent study (MMS, 2008) quoted above also essentially precludes development in multiyear ice areas in water depths greater than 100 m (330 ft). All of the technically recoverable oil and gas resources of the Chukchi Sea Planning area are considered to be located south of the 100-m (330-ft) isobath west of Hanna submarine canyon or the 500-m (1,650-ft) isobath east of the canyon (Figure 3). The use of the 500-m (1,650-ft) isobath east of the Hanna submarine canyon reflects the fact that that area is simply a westward extension of the Beaufort Sea continental shelf and slope, where a 500-m- (1,650-ft)-isobath cutoff also was used.

## Regional Geological and Geophysical Studies

Previous investigations of the Arctic continental shelves were carried out primarily by Arthur Grantz and colleagues of the U.S. Geological Survey. These pioneer studies, including those of Grantz et al. (1975, 1979, 1981, 1982a,b, 1987, 1990); Grantz and Eittreim (1979); Grantz and May (1982, 1987); and Eittreim and Grantz (1979) established the framework from which all subsequent studies have been extended. Published studies based on industry data by Thurston and Theiss (1987), Craig, Sherwood, and Johnson (1985), Hubbard, Edrich, and Rattey (1987), Haimla et al. (1990), and Sherwood et al. (2002) have improved our understanding of the region.

## Leasing and Exploration History

Petroleum exploration of Alaska's North Slope (that area between the Brooks Range and the Beaufort Sea coast) began with the establishment of the Naval Petroleum Reserve No. 4 (NPR-4) in 1923. As a result of drilling from 1944 to 1953, small oil fields were discovered at Umiat, Simpson, and Fish Creek. Gas fields were discovered at Gubik, South Barrow, Meade, Square Lake, Oumalik, and Wolf Creek. All of these fields occur in sandstone reservoirs of the Brookian sequence. The Brookian sequence and other major geological sequences are shown in relative positions in the geologic columns of Figures 6 and 7. The South Barrow gas field supplied fuel to the Naval Arctic Research Lab for a number of years. The field still provides gas to the village of Barrow. In 1975, federally-funded exploration resumed in NPR-4 and continued for 7 years. This drilling program found gas fields and some oil shows at East Barrow and Walakpa, both of which provide gas for the village of Barrow. NPR-4 became the National Petroleum Reserve in Alaska (NPRA) in 1977 when the U.S. Department of the Interior received jurisdiction of the area.

The State of Alaska held the first competitive lease sale on the North Slope in late 1964. The State held a second competitive lease sale in 1965 that included the Prudhoe Bay structure. Atlantic Richfield Company and Humble Oil announced the discovery of the Prudhoe Bay field in 1968 after drilling the Prudhoe Bay State 1 well. Other oil fields discovered during the period of accelerated exploration activity following the Prudhoe Bay discovery include Kuparuk (1969), West Sak (1969), Milne Point (1970), Flaxman Island (1975), Point Thomson (1977), and Sag Delta-Duck Island (1978) (later called the Endicott pool in the Duck island unit).

Petroleum exploration of the Beaufort Sea Planning Area began with a joint State of Alaska— Federal offshore lease sale in December 1979 (Sale BF). Nine additional lease sales have been held since (Sales 71, 87, 97, 124, 144, 170, 186, 195, and 202), with the most recent in 2007. The leases active as of August 2007 in the Beaufort Sea Planning Area are shown in Figure 4.

Industry investigations of the Beaufort Sea Planning Area resulted in the collection of 158,400 line kilometers (99,000 line miles) of 2D (2-dimensional, or traditional) seismic data and approximately 1,550 $km^2$ (600 $mi^{2)}$ of 3D (3-dimensional) seismic surveys (3D survey locations remain proprietary).

A total of 36 wells have been drilled on the Beaufort Sea leases. These wells led to a number of oil discoveries: At Tern Island (now Liberty field), oil was discovered in the Mississippian Kekiktuk Formation of the Endicott Group (part of the Ellesmerian sequence). At Seal Island (Northstar field), oil was discovered in the Triassic Ivishak Formation (part of the Ellesmerian

sequence). The Hammerhead and Kuvlum wells discovered oil in Cenozoic sandstones (part of the Brookian sequence). Two wells at the Sandpiper prospect encountered significant quantities of oil and gas in Sadlerochit Group sandstones (part of the Ellesmerian sequence). The Phoenix and Antares wells encountered minor amounts of oil in the Sag River Formation (part of the Ellesmerian sequence). Mukluk and Mars wells encountered shows of oil in the Sadlerochit Group (part of Ellesmerian sequence). The Galahad well encountered minor amounts of gas and an oil show in Cenozoic sandstones, and the McCovey well encountered oil shows in core samples from Cenozoic turbiditic sandstones (in both cases, part of the Brookian sequence).

Four lease sales were held for different parts of Chukchi shelf in 1988 and 1991. Two lease sales (109, 126) were held in the pre-1996 Chukchi Sea Planning Area while two sales were also held in 1988 and 1991 in the adjacent pre-1996 Beaufort Sea Planning Area (sales 97, 124). (The pre-1996 planning areas met at a border in the northeast Chukchi shelf along 71° N. latitude and 162° W. longitude, as shown in Sherwood et al., 1998:Figure 13.2, p. 169). The four sales issuing leases on the Chukchi shelf together collected $512 million in total high bids on 483 tracts (approximately 2.7 million acres). Industry, primarily Shell Oil, directed most of the high bids to just a few of the 42 prospects leased on the Chukchi shelf. Eighty-five percent of the $512 million dollars that were bid in all four sales targeted the five prospects that eventually were drilled (Burger, Klondike, Crackerjack, Popcorn, Diamond; Figure 3). Burger prospect involves Rift sequence reservoirs; the other four prospects all involve Ellesmerian sequence reservoirs.

Chukchi Sea Sale 193 was held on February 6, 2008, 17 years after the preceding sale (126) and garnered $2,662,059,883 in total high bids for 488 blocks or approximately 29 million acres. Twenty-seven prospects received bids in Sale 193. A map showing the locations of the blocks receiving bids is shown in Figure 5. Sale 193 was dominated by Shell Gulf of Mexico, Inc., which submitted high (apparent winning) bids of $2,117,821,183 on 275 blocks. Most (91%) of the high bids, totaling approximately $2,433,309,630, targeted 164 blocks over the Burger, Crackerjack, and Klondike structures, previously tested by the exploration wells drilled in the 1989-1991 exploration phase. In contrast to the earlier sales where they received approximately $41 million in high bids, the Popcorn and Diamond structures received only about $6 million in high bids in Sale 193.

Industry investigations of the Chukchi Sea Planning Area prior to the 1988 and 1991 lease sales resulted in the collection of 160,900 line km (100,000 line-miles) of 2D seismic-reflection data. In addition, comprehensive gravimetric, magnetic, thermal, and geochemical surveys also were conducted. In anticipation of Chukchi Sea Sale 193, 3D seismic surveys were conducted during the 2006 and 2007 open-water seasons (late summer-fall) in the Chukchi Sea. These 3D surveys covered approximately 4,662 $km^2$ (1,800 $mi^2$) (the survey locations are proprietary).

A total of 5 exploratory wells, at an average cost of $35 million apiece (Tarrant, 1991), were drilled on Chukchi shelf from 1989-1991 ("Klondike" OCS Y-1482-1 [1989]; "Burger" OCS Y-1413-1 [1989-1990]; "Popcorn" OCS Y-1275-1 [1989-1990]; "Crackerjack" OCS Y-1320-1 [1990-1991]; and "Diamond" OCS Y-0996-1 [1991]. Three wells were drilled over two open-water seasons. Four of the wells (Burger, Klondike, Crackerjack, and Popcorn) encountered pooled hydrocarbons. Burger prospect is estimated to contain

discovered resources of 14.038 Tcf gas and 724 Mmb of condensate (Craig and Sherwood, 2004). In Sale 193, Burger prospect was targeted by $1,562,343,791 in total high bids.

**Geological Setting of Arctic Continental Shelf Basins and Oil and Gas Potential of Geologic Sequences**

North Slope discovered resources are scattered among more than 30 oil and gas fields, but all of the present commercial development is in the several oil fields in the Prudhoe Bay area (Figure 2). Many, but not all, of the key oil-source and reservoir sequences of northern Alaska (highlighted in Figures 6 and 7) extend directly into offshore assessment provinces. Because of the presence offshore of these rich oil source rocks and commercially successful petroleum reservoirs, and because of the abundance of untested potential traps in the offshore, the Beaufort and Chukchi Sea shelves are considered high potential areas.

The rocks that underlie the Beaufort and Chukchi continental shelves may be simplified into four main groups for purposes of linking the regional stratigraphy to petroleum reservoirs that form the exploration targets offshore (Figures 6 and 7). These include the ***Franklinian***, ***Ellesmerian***, ***Rift***, and ***Brookian*** sequences.

In northern Alaska and most of the Beaufort and Chukchi shelves, acoustic basement is mostly represented by highly deformed and metamorphosed rocks (mostly flysch) of Late Devonian and older age that offer negligible potential for oil and gas. The metamorphic rocks that form acoustic basement beneath Arctic Alaska are generally assigned to the ***Franklinian sequence*** (Lerand, 1973), shown as synonymous with acoustic basement in Figures 6 and 7. The Franklinian rocks, which underlie northern Alaska, were deformed by a regional event widely recognized in many parts of Arctic North America termed the Ellesmerian orogeny (Late Devonian). Two exceptions among the hydrocarbon-barren Franklinian sequence metamorphites are noted: First, there is an area of relatively undeformed and seismically coherent (well-defined stratification in seismic data) Franklinian rocks that underlie the northeastern Chukchi shelf. The undeformed Franklinian sequence beneath the northeast Chukchi shelf has not been penetrated by any wells but was recognized in seismic data and termed the Northeast Chukchi "basin" by Craig, Sherwood, and Johnson (1985). The Northeast Chukchi "basin" is not actually a basin in the usual sense. It appears to be fault-bounded and may be a tectonic fragment of the Franklinian basin of Arctic Canada, with which it was once continuous, but now is isolated because of rifting, continental breakup, and formation of the oceanic Canada basin (Sherwood, 1994). Second, there are seismically-transparent rocks with oil-bearing carbonates beneath the Point Thomson gas-condensate pool onshore adjacent to the southeastern part of the Beaufort Sea Planning Area (located in Figure 2). Beneath the Point Thomson field, oil and gas were recovered from the Franklinian sequence by flow tests.

To date, no commercial petroleum development has taken place from the Franklinian sequence in northern Alaska, although some production has occurred from Franklinian rocks at two fields in Arctic Canada. Two oil and gas plays ("plays" are groups of petroleum pools that are genetically linked as families) are associated with the Franklinian sequence in the Arctic offshore planning areas (Beaufort play 1 and Chukchi play 23; Tables 4 and 8). The mean, risked BOE resources of the two Franklinian sequence plays aggregate to 363 Mmbbl-oe (oil equivalent) or 0.9% of overall Arctic offshore undiscovered

resources.

Deposition of the ***Ellesmerian sequence*** began in Late Devonian or Early Mississippian time, and in Arctic Alaska, the Ellesmerian strata rest unconformably on an erosion surface that incised deformed Franklinian rocks. The east-trending basin beneath the Alaska North Slope in which Ellesmerian strata accumulated is termed the Arctic Alaska basin. The Arctic Alaska basin extends north into the Arctic platform and thence to its edge offshore beneath the Beaufort shelf (located in Figure 8). Beneath the Chukchi shelf, the Ellesmerian sequence fills a north-trending rift basin called Hanna trough (Grantz et al., 1982a) that extends north from the west end of the Arctic Alaska basin (Figure 8). The Ellesmerian cycle of sedimentation is capped by regional erosion events and unconformities that mark the base of the overlying "Rift" sequence (Figures 6 and 7).

The largest oil field in North America—the Prudhoe Bay Ivishak Formation pool (original reserves,13,621 Mmbbl)—produces from Ellesmerian sequence sandstones. The Duck Island unit-Endicott pool (592 Mmbbl), the Northstar field (206 Mmbbl), and the Liberty field (105 Mmbbl), among others, are also housed in Ellesmerian sequence reservoirs. The spectacular success of the petroleum reservoirs of the Ellesmerian sequence has driven much of the frontier exploration over the past 40 years in areas near and far from the oil fields of the Prudhoe Bay area.

Nine oil and gas plays are associated with the Ellesmerian sequence rocks in the Arctic offshore planning areas (Beaufort plays 4-6; Chukchi plays 1-6; Tables 4 and 7). The mean, risked BOE resources of the nine Ellesmerian sequence plays aggregate to 10,506 Mmbbl-oe or 25% of overall Arctic offshore undiscovered resources.

Rifting began in Early Jurassic time along the Beaufort continental margin and then extended into the northern Chukchi shelf in mid-Jurassic time. This rift system widened to ultimately create the Canada oceanic basin, but near the Alaska margin the rift-fault structures were buried beneath the North Chukchi and Nuwuk basins. Tectonic disturbance of the crust near the active rift zone influenced patterns of sedimentation far to the south of the zone, as shown in the map of the rift system in Figure 9. Grabens and flexural sags near the rift were filled with thick sequences of clastic sediments, some probably of local derivation and rich in detritus recycled from Ellesmerian rocks exposed on uplifts within the rift zone. These strata represent a distinct tectonic process and have been variously distinguished as the ***Rift sequence*** (Craig, Sherwood, and Johnson, 1985), the ***Beaufortian sequence*** (Hubbard, Edrich, and Rattey, 1987), or the ***Barrovian sequence*** (Carman and Hardwick, 1983). Because it is more general, we adopt the term "Rift sequence" for rocks deposited during the rifting in the Arctic offshore. The Rift sequence ranges in age from Early Jurassic to Early Cretaceous (Aptian to Albian) in the Arctic offshore and we extend the term to include rocks deposited at the same time to the south and beyond the influence of the rift zone in northern Alaska ("stable shelf" and "deep basin" areas of Figure 9).

The second-largest producing oil field in North America—the Kuparuk River field of the North Slope (original reserves, 2,870 Mmbbl)—produces from a Rift sequence reservoir. The Point Thomson (8 Tcf, 295 Mmbbl), Milne Point (580 Mmbbl), Niakuk (101 Mmbbl), Alpine (478 Mmbbl), and Point McIntyre (569 Mmbbl) fields of the North Slope are all lodged in Rift sequence sandstones.

Four oil and gas plays are associated with Rift sequence rocks in the Arctic offshore planning areas (Beaufort play 7 and

Chukchi plays 7-9; Tables 4 and 7). The mean, risked BOE resources of the four Rift sequence plays aggregate to 11,243 Mmbbl-oe or 27% of overall Arctic offshore undiscovered resources.

The Brookian-Chukotkan orogeny, ranging in possible age from Middle Jurassic to Early Cretaceous (ca. 175 to 115 Ma), ended the Jurassic to Cretaceous rift-controlled phase of sedimentation south of the Barrow arch (located in Figure 9) and completely reorganized the tectonic framework of northern Alaska and the continental shelves. Cretaceous and Tertiary rocks of the ***Brookian sequence***, consisting mostly of sediments shed from mountain belts like the Brooks Range that were created during the Brookian-Chukotkan orogeny, fill several (Colville, Nuwuk, North Chukchi, and Kaktovik) basins north of the mountain belts (Figure 10). Continuing deformations folded the rocks in southern parts of the Colville basin and the Kaktovik basin north of ANWR. This folding event also reactivated north-trending basement faults that complexly structured the overlying Brookian strata on Chukchi platform (Figure 11) in the Chukchi Sea Planning Area.

Brookian sequence production through 2005 accounted for only approximately 1.0% of aggregate North Slope oil production (Alaska Division of Oil and Gas, 2006), although vast deposits of heavy or asphaltic oil (e.g., West Sak-Ugnu pools, 40,000 Mmbbl in place) occur within Brookian sequence sandstone reservoirs. The recoverable oil reserves associated with Brookian sequence fields are generally small and are typified by the West Sak (original reserves, 429 Mmbbl), Tabasco (21 Mmbbl), Tarn (121 Mmbbl), and Meltwater (17 Mmbbl) fields.

Twenty-seven oil and gas plays are associated with the Brookian and Hope basin sequences in the Arctic offshore planning areas (Beaufort plays 8-16; Chukchi plays 10-29; Tables 4 and 7). The mean, risked BOE resources of the 27 Brookian sequence plays aggregate to 20,069 Mmbbl-oe or 47% of overall Arctic offshore undiscovered resources.

**Potential Traps**

The Beaufort Sea and Chukchi Sea Planning Areas are underlain by several distinct basins that are varyingly deformed by listric faults, transtensional faults, rift-extension faults, and a fold and thrust belt. These deformations have shaped the subsurface rock layers into a large number of potential traps that can be readily mapped in conventional 2D seismic data. The current MMS inventory contains 1,129 mapped prospects (generally anticlines, fault traps, or stratigraphic wedge-outs) that remain to be drilled in the Arctic planning areas. These prospects range in mapped closure areas from tens of acres to hundreds of thousands of acres, some larger in map area than the two largest oil fields of the Alaska North Slope, as illustrated by the prospect area rank plot of Figure 12. Twelve prospects exceed 150,000 acres in area and 95 prospects exceed 40,000 acres in area. Even with the high cost challenges associated with operations in these frontier areas, some prospects are clearly sufficiently large, if charged with petroleum, to possibly warrant development.

**Oil and Gas Resources of Arctic Offshore Planning Areas**

The 2006 assessment of the Beaufort Sea and Chukchi Sea Planning Areas identified a total of 43 exploration plays, several of which are correlative between the areas. As reported in Table 1, the mean, risked, technically-recoverable, undiscovered hydrocarbon energy endowment of the Arctic planning area is 42,180 Mmbbl-oe. As also shown in Table 1, the Arctic

offshore planning areas are collectively oil-prone, with 56% of the overall undiscovered hydrocarbon energy endowment consisting of oil and condensate (the latter liquids from produced gas).

Table 2 shows the undiscovered resource quantities, by commodity, for the ***Beaufort Sea Planning Area***. Mean risked, undiscovered total gas (sum of free gas and solution gas in oil) resources total 27.645 Tcf but could range up to a maximum (F05) potential of 72.178 Tcf. Mean risked, undiscovered liquid petroleum (sum of free oil and condensate from gas) resources are estimated at 8,224 Mmbbl but could range up to a maximum (F05) potential of 23,235 Mmbbl. A cumulative probability graph for liquids, total gas, and total energy (BOE) in the Beaufort Sea Planning Area is presented in Figure 13 and shows the full spectrum of undiscovered recoverable resource potential.

The 14 quantified plays in the Beaufort Sea Planning Area are estimated to contain a maximum of 344 oil, mixed-case, or gas pools. Table 3 lists the sizes in BOE of the 10 largest pools in the Beaufort Sea Planning Area. Two of these pools are estimated to contain mean conditional (unrisked) resources in excess of 1,000 Mmbbl-oe. The largest pool is found in Brookian sequence play 16, which includes the offshore extension of the foreland fold belt that underlies northern ANWR (Table 3). The mean conditional (unrisked) size of the largest undiscovered pool in the Beaufort Sea Planning Area is 2,144 Mmbbl-oe. At maximum (F05) size, this same pool is estimated to contain conditional resources of 6,044 Mmbbl-oe.

Table 4 summarizes the resource potential for each of the 14 Beaufort Sea plays by commodity. A complete description of the Beaufort Sea geologic plays and their petroleum potential is given by MMS (2006a) at the web site posting at http://www.mms.gov/alaska/re/reports/2006Asmt/BSGA/bsga.HTM.

Economically-recoverable oil for the Beaufort Sea Planning Area ranges from 0 Mmbbl at $8/bbl to 6,920 Mmbbl at $80/bbl (the highest price scenario entertained in the 2006 assessment). Economically recoverable natural gas ranges from 0 Tcf at $1.21/mcf to 19.97 Tcf at $12.10/mcf. Complete tabulations of the economic assessment results at all price scenarios for the Beaufort Sea are given by MMS (2006b) at http://www.mms.gov/alaska/re/reports/2006Asmt/2006_Assessment_Risked_Tables.pdf. The full ranges of economically recoverable oil and gas at a range of market prices between $0 and $80 per barrel of oil and $0 and $12.10 per thousand cubic feet of gas (mcf) are shown by the price-supply graph for the Beaufort Sea in Figure 14.

The economic modeling indicates that some of the hypothetical petroleum pools in the Beaufort Sea are sufficiently large at high oil prices to overcome the high costs of development in the harsh Arctic offshore environment. It is therefore reasonable to forecast that some fraction of the Beaufort Sea oil and gas resources will be discovered and commercially developed in the coming years.

Table 5 shows the undiscovered resource quantities for the ***Chukchi Sea Planning Area***. Mean risked, undiscovered total gas (sum of free gas and solution gas in oil) resources total 76.772 Tcf but could range up to a maximum (F05) potential of 209.527 Tcf. Mean risked, undiscovered liquid petroleum (sum of free oil and condensate from gas) resources are estimated at 15,380 Mmbbl but could range up to a maximum (F05) potential of 40,075 Mmbbl. A cumulative probability graph for liquids, total gas, and total energy (BOE) in the Chukchi Sea Planning Area is given in Figure 14 and shows the full spectrum of undiscovered resource potential.

The 27 quantified plays (plays 10 and 29 were assigned negligible resources) in the Chukchi Sea Planning Area are estimated to contain a maximum of 1,406 oil, mixed-case, or gas pools. As shown in Table 6, seven of these pools are estimated to contain mean conditional resources in excess of 1,000 Mmbbl-oe. The largest pool, at 2,183 Mmbbl-oe, is found in Rift sequence play 7, which also hosts the Burger gas discovery. (Burger prospect discovered resources of 14.038 Tcfg and 724 Mmbbl-condensate are estimated to sum to 3,222 Mmbbl-oe [Craig and Sherwood, 2004].) At maximum (F05) size, the largest undiscovered pool is estimated to contain conditional resources of 5,940 Mmbbl-oe. In 1991, Dees (1991) estimated that a 1,000 to 3,000 Mmbbl field would be required to spark development in the Chukchi Sea. The Chukchi Sea Planning Area appears to offer exploration targets that, if charged with petroleum, contain volumes sufficient to warrant economic development.

Tables 7 and 8 report the assessment results in detail for all plays and all petroleum commodities. The top 8 of the 29 Chukchi plays (plays 7, 1, 8, 11, 21, 6, 14 and 5), carry 85 percent of the liquid (free oil and condensate from gas) endowment and 79 percent of the total gas endowment. These eight plays dominate the resource endowment because they offer many large prospects, ready access to petroleum charging systems, broad areas of shallow burial with commensurate extensive preservation of reservoir pore systems, and in some cases (plays 5, 7, 8, 9, and 11) geological success demonstrated by offshore drilling. These eight plays will likely form the primary targets of future petroleum exploration on Chukchi shelf.

A complete description of the Chukchi Sea geologic plays and their petroleum potential is given by MMS (2006c) at the web site posting at http://www.mms.gov/alaska/re/reports/2006Asmt/CHGA/chga.HTM.

Economically-recoverable oil for the Chukchi Sea Planning Area ranges from 0 Mmbbl at $8/bbl to 12,000 Mmbbl at $80/bbl (the highest price scenario entertained in the 2006 assessment). Economically recoverable natural gas ranges from 0 Tcf at $1.21/mcf to 54.44 Tcf at $12.10/mcf. Complete tabulations of the economic assessment results at all price scenarios for the Chukchi Sea are given by MMS (2006b) at http://www.mms.gov/alaska/re/reports/2006Asmt/2006_Assessment_Risked_Tables.pdf The full ranges of economically recoverable oil and gas at a range of market prices between $0 and $80 per barrel of oil and $0 and $12.10 per thousand cubic feet of gas (mcf) are shown by the price-supply graph for the Chukchi Sea shown in Figure 16.

Like the Beaufort Sea, the economic modeling for the Chukchi Sea indicates that some pools are sufficiently large, at high oil prices, to overcome the high costs of development in the harsh arctic offshore environment. It is therefore reasonable to forecast that some fraction of the Beaufort and Chukchi Sea oil and gas resources will be discovered and commercially developed in the foreseeable future.

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**Table 1 Undiscovered Oil and Gas Resources of Arctic Alaska Offshore Planning Areas***

| Assessment Area | Total Energy Endowment (billions of barrels equivalent) | Oil and Natural Gas Liquids (billions of barrels) | Natural Gas (trillions of cubic feet) | Oil/Gas on (energy-equivalent basis, %) |
|---|---|---|---|---|
| Chukchi Sea Planning Area[1] | 29.04 | 15.38 | 76.77 | 53 |
| Beaufort Sea Planning Area[1] | 13.14 | 8.22 | 27.64 | 63 |
| **Totals** | **42.18** | **23.60** | **104.41** | **56** |

*Mean, risked, undiscovered, technically recoverable oil and gas resources, Chukchi Sea and Beaufort Sea Planning Areas

**Sources:** [1]USDOI, MMS (2006), Arctic Offshore Planning Areas; BOE for gas assumes 5,620 cubic feet of gas = 1 barrel oil-equivalent

**Table 2 Undiscovered Oil and Gas Resources, Beaufort Sea Planning Area**

| **Beaufort Sea OCS Planning Area, 2006 Assessment, Undiscovered Technically-Recoverable Oil & Gas** | | | |
|---|---|---|---|
| Assessment Results as of November 2005 | | | |
| **Resource Commodity (Units)** | **Resources *** | | |
| | **F95** | **Mean** | **F05** |
| BOE (Mmbbl-oe) | 527 | 13,142 | 36,078 |
| Total Gas (Tcfg) | 0.649 | 27.645 | 72.178 |
| Total Liquids (Mmbbl) | 412 | 8,224 | 23,235 |
| Free Gas** (Tcfg) | 0.322 | 23.792 | 60.965 |
| Solution Gas (Tcfg) | 0.328 | 3.853 | 11.213 |
| Oil (Mmbbl) | 405 | 7,224 | 20,625 |
| Condensate (Mmbbl) | 7 | 999 | 2,611 |
| ** Risked, Technically-Recoverable* | | | |
| *** Free Gas Includes Gas Cap and Non-Associated Gas* | | | |
| *F95 = 95% chance that resources will equal or exceed the given quantity* | | | |
| *F05 = 5% chance that resources will equal or exceed the given quantity* | | | |
| *BOE = total hydrocarbon energy, expressed in barrels-of-oil-equivalent, where 1 barrel of oil = 5,620 cubic feet of natural gas* | | | |
| *Mmbbl = millions of barrels* | | | |
| *Tcf = trillions of cubic feet* | | | |

**Table 3 Sizes (Unrisked) of Ten Largest Undiscovered Pools, Beaufort Sea Planning Area**

| Beaufort Sea OCS Planning Area, Alaska, 2006 Assessment, Conditional BOE Sizes of Ten Largest Pools | | | | |
|---|---|---|---|---|
| Assessment Results as of November 2005 | | | | |
| **Pool Rank** | **Play Number** | **BOE Resources * (Mmbbl-oe)** | | |
| | | **F95** | **Mean** | **F05** |
| **1** | 16 | 289 | 2144 | 6044 |
| **2** | 12 | 296 | 1602 | 4553 |
| **3** | 7 | 77 | 838 | 3287 |
| **4** | 6 | 129 | 834 | 2612 |
| **5** | 16 | 178 | 795 | 2287 |
| **6** | 12 | 167 | 672 | 1591 |
| **7** | 8 | 34 | 542 | 2164 |
| **8** | 14 | 75 | 531 | 1705 |
| **9** | 16 | 129 | 437 | 1106 |
| **10** | 9 | 23 | 423 | 1490 |
| ** Conditional, Technically-Recoverable, Millions of Barrels Energy-Equivalent (Mmbbl-oe), from "PSRK.out" file* | | | | |
| *F95 = 95% chance that resources will equal or exceed the given quantity* | | | | |
| *F05 = 5% chance that resources will equal or exceed the given quantity* | | | | |
| *BOE = total hydrocarbon energy, expressed in barrels-of-oil-equivalent, where 1 barrel of oil = 5,620 cubic feet of natural gas* | | | | |

**Table 4. Summary of Beaufort Sea Assessment Results for Ultimate Technically Recoverable Resources (UTRR), by Play.**

## 2006 Assessment Results for Beaufort Sea OCS Planning Area

**Risked, Undiscovered, Technically Recoverable Oil and Gas Resources, as of November 2005**

| | | BOE Resources (Mmbbl-oe) | | | Oil Resources (Mmbbl) | | | Gas-Condensate Liquid Resources (Mmbbl) | | | Free* Gas Resources (Tcfg) | | | Solution Gas Resources (Tcfg) | | | Total Liquid Resources (Mmbbl) | | | Total Gas Resources (Tcfg) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Play Number | Play Name | F95 | Mean | F05 | F95 | Mean | F05 | F95 | Mean | F05 | F95 | Mean | F05 | F95 | Mean | F05 | F95 | Mean | F05 | F95 | Mean | F05 |
| 1 | Undeformed Pre-Mississippian Basement | 0 | 31 | 117 | 0 | 15 | 56 | 0 | 1 | 4 | 0.000 | 0.066 | 0.260 | 0.000 | 0.016 | 0.060 | 0 | 16 | 60 | 0.000 | 0.083 | 0.320 |
| 4 | Endicott | 46 | 354 | 1,076 | 32 | 255 | 780 | 1 | 6 | 16 | 0.038 | 0.251 | 0.722 | 0.032 | 0.273 | 0.850 | 33 | 261 | 796 | 0.070 | 0.524 | 1.572 |
| 5 | Lisburne | 0 | 179 | 864 | 0 | 138 | 684 | 0 | 1 | 5 | 0.000 | 0.071 | 0.296 | 0.000 | 0.153 | 0.688 | 0 | 139 | 689 | 0.000 | 0.224 | 0.983 |
| 6 | Upper Ellesmerian | 366 | 1,660 | 3,891 | 270 | 1,236 | 2,893 | 4 | 18 | 37 | 0.240 | 0.955 | 1.996 | 0.274 | 1.327 | 3.399 | 275 | 1,254 | 2,930 | 0.514 | 2.282 | 5.395 |
| 7 | Rift | 0 | 1,157 | 3,296 | 0 | 773 | 2,385 | 0 | 27 | 56 | 0.000 | 1.153 | 2.190 | 0.000 | 0.850 | 2.614 | 0 | 801 | 2,441 | 0.000 | 2.002 | 4.804 |
| 8 | Brookian Faulted Western Topset | 0 | 614 | 2,234 | 0 | 152 | 672 | 0 | 90 | 312 | 0.000 | 2.056 | 6.883 | 0.000 | 0.034 | 0.144 | 0 | 242 | 983 | 0.000 | 2.090 | 7.027 |
| 9 | Brookian Unstructured Western Topset | 0 | 475 | 1,786 | 0 | 373 | 1,410 | 0 | 17 | 67 | 0.000 | 0.390 | 1.423 | 0.000 | 0.082 | 0.316 | 0 | 390 | 1,477 | 0.000 | 0.473 | 1.739 |
| 10 | Brookian Faulted Western Turbidite | 0 | 232 | 815 | 0 | 17 | 48 | 0 | 42 | 151 | 0.000 | 0.955 | 3.415 | 0.000 | 0.012 | 0.042 | 0 | 60 | 200 | 0.000 | 0.967 | 3.457 |
| 11 | Brookian Unstructured Western Turbidite | 0 | 218 | 777 | 0 | 151 | 536 | 0 | 10 | 33 | 0.000 | 0.217 | 0.778 | 0.000 | 0.107 | 0.387 | 0 | 161 | 569 | 0.000 | 0.324 | 1.165 |
| 12 | Brookian Faulted Eastern Topset | 0 | 2,831 | 7,114 | 0 | 615 | 1,999 | 0 | 438 | 1,047 | 0.000 | 9.855 | 22.439 | 0.000 | 0.135 | 0.421 | 0 | 1,053 | 3,046 | 0.000 | 9.991 | 22.860 |
| 13 | Brookian Unstructured Eastern Topset | 116 | 639 | 1,575 | 102 | 570 | 1,422 | 2 | 9 | 19 | 0.043 | 0.211 | 0.449 | 0.022 | 0.126 | 0.309 | 104 | 579 | 1,440 | 0.065 | 0.336 | 0.758 |
| 14 | Brookian Faulted Eastern Turbidite | 0 | 941 | 2,354 | 0 | 65 | 144 | 0 | 175 | 438 | 0.000 | 3.892 | 9.842 | 0.000 | 0.046 | 0.120 | 0 | 240 | 581 | 0.000 | 3.938 | 9.962 |
| 15 | Brookian Unstructured Eastern Turbidite | 0 | 168 | 533 | 0 | 116 | 369 | 0 | 7 | 24 | 0.000 | 0.168 | 0.529 | 0.000 | 0.082 | 0.258 | 0 | 123 | 393 | 0.000 | 0.250 | 0.787 |
| 16 | Brookian Foldbelt | 0 | 3,645 | 9,647 | 0 | 2,748 | 7,228 | 0 | 157 | 401 | 0.000 | 3.552 | 9.743 | 0.000 | 0.609 | 1.605 | 0 | 2,905 | 7,628 | 0.000 | 4.161 | 11.348 |
| **Sum of All Plays**** | | **527** | **13,142** | **36,078** | **405** | **7,224** | **20,625** | **7** | **999** | **2,611** | **0.322** | **23.792** | **60.965** | **0.328** | **3.853** | **11.213** | **412** | **8,224** | **23,235** | **0.649** | **27.645** | **72.178** |

** Free gas, occurring as gas caps associated with oil and as oil-free gas pools (non-associated gas).*

*** Values as reported out of Basin Level Analysis-Geologic Scenario aggregation module in GRASP, "Volume Ordered" aggregation option. Total liquids and total gas values were obtained by summing resource values for means and fractiles of component commodities. Play resource values are rounded and may not sum to totals reported from basin aggregation.*

*BOE, total energy, in millions of barrels (5,620 cubic feet of gas per barrel of oil, energy-equivalent); Mmbbl, millions of barrels of oil or liquids; Tcfg, trillions of cubic feet of natural gas*

**Table 5 Undiscovered Oil and Gas Resources, Chukchi Sea Planning Area**

| Chukchi Sea OCS Planning Area, 2006 Assessment, Undiscovered Technically-Recoverable Oil & Gas | | | |
|---|---|---|---|
| Assessment Results as of November 2005 | | | |
| **Resource Commodity (Units)** | **Resources *** | | |
| | **F95** | **Mean** | **F05** |
| BOE (Mmbbl-oe) | 4,152 | 29,041 | 77,357 |
| Total Gas (Tcfg) | 10.316 | 76.772 | 209.527 |
| Total Liquids (Mmbbl) | 2,317 | 15,380 | 40,075 |
| Free Gas** (Tcfg) | 8.070 | 57.140 | 156.879 |
| Solution Gas (Tcfg) | 2.246 | 19.632 | 52.648 |
| Oil (Mmbbl) | 1,895 | 12,381 | 31,841 |
| Condensate (Mmbbl) | 421 | 2,999 | 8,234 |
| ** Risked, Technically-Recoverable* | | | |
| *** Free Gas Includes Gas Cap and Non-Associated Gas* | | | |
| *F95 = 95% chance that resources will equal or exceed the given quantity* | | | |
| *F05 = 5% chance that resources will equal or exceed the given quantity* | | | |
| *BOE = total hydrocarbon energy, expressed in barrels-of-oil-equivalent, where 1 barrel of oil = 5,620 cubic feet of natural gas* | | | |
| *Mmbbl = millions of barrels* | | | |
| *Tcf = trillions of cubic feet* | | | |

**Table 6. Sizes (Unrisked) of Ten Largest Undiscovered Pools, Chukchi Sea Planning Area**

| Chukchi Sea OCS Planning Area, Alaska, 2006 Assessment, Conditional BOE Sizes of Ten Largest Pools | | | | |
|---|---|---|---|---|
| Assessment Results as of November 2005 | | | | |
| **Pool Rank** | **Play Number** | **BOE Resources * (Mmbbl-oe)** | | |
| | | **F95** | **Mean** | **F05** |
| **1** | 7 | 475 | 2183 | 5940 |
| **2** | 1 | 530 | 1985 | 5375 |
| **3** | 8 | 202 | 1862 | 7670 |
| **4** | 14 | 115 | 1694 | 5787 |
| **5** | 6 | 273 | 1276 | 3355 |
| **6** | 21 | 311 | 1075 | 2766 |
| **7** | 1 | 298 | 1029 | 2147 |
| **8** | 7 | 280 | 984 | 2126 |
| **9** | 11 | 268 | 856 | 2100 |
| **10** | 25 | 178 | 794 | 2217 |
| ** Conditional, Technically-Recoverable, Millions of Barrels Energy-Equivalent (Mmbbl-oe), from "PSRK.out" file* | | | | |
| *F95 = 95% chance that resources will equal or exceed the given quantity* | | | | |
| *F05 = 5% chance that resources will equal or exceed the given quantity* | | | | |
| *BOE = total hydrocarbon energy, expressed in barrels-of-oil-equivalent, where 1 barrel of oil = 5,620 cubic feet of natural gas* | | | | |

**Table 7. Summary of Chukchi Sea Assessment Results for Ultimate Technically Recoverable Resources (UTRR), by Play, for Plays 1-19**

**2006 Assessment Results for Chukchi Sea OCS Planning Area**

**Risked, Undiscovered, Technically Recoverable Oil and Gas Resources, as of November 2005**

| | | BOE Resources (Mmbbl-oe) | | | Oil Resources (Mmbbl) | | | Gas-Condensate Liquid Resources (Mmbbl) | | | Free* Gas Resources (Tcfg) | | | Solution Gas Resources (Tcfg) | | | Total Liquid Resources (Mmbbl) | | | Total Gas Resources (Tcfg) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Play Number** | **Play Name** | **F95** | **Mean** | **F05** | **F95** | **Mean** | **F05** | **F95** | **Mean** | **F05** | **F95** | **Mean** | **F05** | **F95** | **Mean** | **F05** | **F95** | **Mean** | **F05** | **F95** | **Mean** | **F05** |
| **1** | **Endicott-Chukchi Platform** | 0 | 4,829 | 10,910 | 0 | 2,255 | 5,469 | 0 | 377 | 753 | 0.000 | 6.976 | 13.175 | 0.000 | 5.371 | 13.173 | 0 | 2,632 | 6,222 | 0.000 | 12.347 | 26.348 |
| **2** | **Endicott-Arctic Platform** | 0 | 122 | 516 | 0 | 9 | 37 | 0 | 26 | 110 | 0.000 | 0.475 | 2.013 | 0.000 | 0.016 | 0.058 | 0 | 35 | 147 | 0.000 | 0.491 | 2.072 |
| **3** | **Lisburne Carbonates** | 0 | 213 | 933 | 0 | 103 | 462 | 0 | 13 | 55 | 0.000 | 0.249 | 1.013 | 0.000 | 0.295 | 1.326 | 0 | 116 | 517 | 0.000 | 0.544 | 2.339 |
| **4** | **Ellesmerian-Deep Gas** | 0 | 198 | 719 | 0 | 0 | 0 | 0 | 25 | 90 | 0.000 | 0.977 | 3.539 | 0.000 | 0.000 | 0.000 | 0 | 25 | 90 | 0.000 | 0.977 | 3.539 |
| **5** | **Sadlerochit Gp.-Chukchi Platform** | 357 | 1,378 | 2,880 | 129 | 439 | 892 | 36 | 166 | 355 | 0.702 | 3.065 | 6.597 | 0.374 | 1.279 | 2.582 | 165 | 605 | 1,247 | 1.076 | 4.344 | 9.179 |
| **6** | **Sadlerochit Gp.-Arctic Platform** | 0 | 1,573 | 4,933 | 0 | 539 | 1,513 | 0 | 202 | 678 | 0.000 | 3.719 | 12.755 | 0.000 | 0.953 | 2.658 | 0 | 741 | 2,191 | 0.000 | 4.672 | 15.413 |
| **7 ***** | **Rift Sequence-Active Margin** | 1,953 | 6,251 | 12,902 | 1,052 | 3,354 | 6,799 | 162 | 541 | 1,172 | 3.145 | 10.034 | 21.216 | 1.008 | 3.209 | 6.496 | 1,214 | 3,895 | 7,971 | 4.153 | 13.243 | 27.712 |
| **8** | **Rift Sequence-Stable Shelf** | 521 | 3,787 | 10,841 | 217 | 1,654 | 4,716 | 51 | 356 | 1,021 | 0.983 | 6.609 | 18.856 | 0.437 | 3.384 | 9.825 | 268 | 2,009 | 5,737 | 1.421 | 9.993 | 28.681 |
| **9** | **Rift Sequence-Deep Gas** | 0 | 48 | 237 | 0 | 0 | 0 | 0 | 6 | 29 | 0.000 | 0.237 | 1.168 | 0.000 | 0.000 | 0.000 | 0 | 6 | 29 | 0.000 | 0.237 | 1.168 |
| **10** | **Herald Arch-Thrust Zone** | Play 10 Assessed with Negligible Resources | | | | | | | | | | | | | | | | | | | | |
| **11** | **Foreland Foldbelt (Lower Brookian)** | 1,238 | 2,853 | 5,077 | 456 | 1,075 | 1,928 | 166 | 381 | 707 | 3.095 | 6.992 | 12.172 | 0.369 | 0.862 | 1.556 | 621 | 1,455 | 2,634 | 3.464 | 7.854 | 13.728 |
| **12** | **Torok Turbidites (Lower Brookian)-Chukchi Wrench Zone** | 51 | 500 | 1,353 | 22 | 172 | 419 | 5 | 62 | 183 | 0.095 | 1.142 | 3.357 | 0.044 | 0.353 | 0.866 | 26 | 234 | 602 | 0.138 | 1.496 | 4.222 |
| **13** | **Nanushuk Topset Sandstones (Lower Brookian)-Chukchi Wrench Zone** | 0 | 325 | 1,280 | 0 | 131 | 516 | 0 | 32 | 130 | 0.000 | 0.595 | 2.319 | 0.000 | 0.313 | 1.243 | 0 | 163 | 647 | 0.000 | 0.908 | 3.562 |
| **14** | **Brookian Sandstones-North Chukchi High** | 0 | 1,455 | 5,309 | 0 | 485 | 1,840 | 0 | 174 | 612 | 0.000 | 3.206 | 11.058 | 0.000 | 1.268 | 4.998 | 0 | 659 | 2,452 | 0.000 | 4.474 | 16.056 |
| **15** | **Topset Sandstones (Lower Brookian)-North Chukchi Basin** | 0 | 414 | 1,356 | 0 | 61 | 165 | 0 | 74 | 255 | 0.000 | 1.360 | 4.703 | 0.000 | 0.209 | 0.560 | 0 | 135 | 420 | 0.000 | 1.569 | 5.263 |
| **16** | **Brookian (Upper and Lower)-Deep Gas** | 0 | 94 | 531 | 0 | 0 | 0 | 0 | 12 | 65 | 0.000 | 0.464 | 2.619 | 0.000 | 0.000 | 0.000 | 0 | 12 | 65 | 0.000 | 0.464 | 2.619 |
| **17** | **Torok Turbidites (Lower Brookian)-Arctic Platform** | 0 | 139 | 338 | 0 | 65 | 150 | 0 | 14 | 38 | 0.000 | 0.257 | 0.658 | 0.000 | 0.081 | 0.188 | 0 | 79 | 187 | 0.000 | 0.337 | 0.846 |
| **18** | **Nanushuk Topset Sandstones (Lower Brookian)-Arctic Platform** | 33 | 510 | 1,436 | 19 | 350 | 992 | 3 | 27 | 76 | 0.050 | 0.505 | 1.388 | 0.013 | 0.242 | 0.684 | 22 | 377 | 1,068 | 0.063 | 0.747 | 2.071 |
| **19** | **Sag Sequence (Upper Brookian)-North Chukchi Basin** | 0 | 22 | 133 | 0 | 9 | 50 | 0 | 3 | 17 | 0.000 | 0.050 | 0.334 | 0.000 | 0.007 | 0.041 | 0 | 12 | 67 | 0.000 | 0.058 | 0.376 |

**Table 8. Summary of Chukchi Sea Assessment Results for Ultimate Technically Recoverable Resources (UTRR), by Play, for Plays 20-29**

## 2006 Assessment Results for Chukchi Sea OCS Planning Area

**Risked, Undiscovered, Technically Recoverable Oil and Gas Resources, as of November 2005**

| | | BOE Resources (Mmbbl-oe) | | | Oil Resources (Mmbbl) | | | Gas-Condensate Liquid Resources (Mmbbl) | | | Free* Gas Resources (Tcfg) | | | Solution Gas Resources (Tcfg) | | | Total Liquid Resources (Mmbbl) | | | Total Gas Resources (Tcfg) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Play Number** | **Play Name** | **F95** | **Mean** | **F05** | **F95** | **Mean** | **F05** | **F95** | **Mean** | **F05** | **F95** | **Mean** | **F05** | **F95** | **Mean** | **F05** | **F95** | **Mean** | **F05** | **F95** | **Mean** | **F05** |
| **20** | **Upper Brookian Turbidites-North Chukchi Basin** | 0 | 73 | 292 | 0 | 13 | 50 | 0 | 12 | 48 | 0.000 | 0.220 | 0.885 | 0.000 | 0.053 | 0.207 | 0 | 25 | 98 | 0.000 | 0.273 | 1.092 |
| **21** | **Upper Brookian Paleo-Valleys** | 0 | 1,612 | 5,532 | 0 | 871 | 3,114 | 0 | 139 | 435 | 0.000 | 2.558 | 8.220 | 0.000 | 0.827 | 2.926 | 0 | 1,010 | 3,548 | 0.000 | 3.386 | 11.146 |
| **22** | **Upper Brookian Intervalley Highs** | 0 | 410 | 1,125 | 0 | 296 | 873 | 0 | 22 | 46 | 0.000 | 0.401 | 0.809 | 0.000 | 0.118 | 0.349 | 0 | 318 | 919 | 0.000 | 0.519 | 1.158 |
| **23** | **Northeast Chukchi Basin-Franklinian** | 0 | 332 | 1,360 | 0 | 39 | 180 | 0 | 66 | 276 | 0.000 | 1.219 | 4.814 | 0.000 | 0.058 | 0.267 | 0 | 105 | 456 | 0.000 | 1.277 | 5.081 |
| **24** | **Lower Brookian-Nuwuk Basin** | 0 | 568 | 2,245 | 0 | 139 | 554 | 0 | 90 | 349 | 0.000 | 1.661 | 6.581 | 0.000 | 0.243 | 0.964 | 0 | 230 | 902 | 0.000 | 1.904 | 7.545 |
| **25** | **Upper Brookian-Nuwuk Basin** | 0 | 1,000 | 3,644 | 0 | 299 | 1,002 | 0 | 144 | 570 | 0.000 | 2.665 | 10.064 | 0.000 | 0.470 | 1.575 | 0 | 442 | 1,573 | 0.000 | 3.135 | 11.639 |
| **26** | **Late Sequence (Oligocene-Pliocene)-Hope Basin** | 0 | 132 | 617 | 0 | 11 | 64 | 0 | 15 | 68 | 0.000 | 0.588 | 2.685 | 0.000 | 0.008 | 0.045 | 0 | 26 | 132 | 0.000 | 0.596 | 2.730 |
| **27** | **Early Sequence (Eocene)-Hope Basin** | 0 | 127 | 557 | 0 | 7 | 38 | 0 | 15 | 64 | 0.000 | 0.584 | 2.511 | 0.000 | 0.009 | 0.044 | 0 | 22 | 102 | 0.000 | 0.593 | 2.555 |
| **28** | **Shallow (<10,000 ft) Basal Sandstones-Hope Basin** | 0 | 72 | 301 | 0 | 4 | 19 | 0 | 8 | 34 | 0.000 | 0.331 | 1.370 | 0.000 | 0.004 | 0.018 | 0 | 13 | 54 | 0.000 | 0.335 | 1.388 |
| **29** | **Deep (>10,000 ft) Basal Sandstones-Hope Basin** | Play 29 Assessed with Negligible Resources | | | | | | | | | | | | | | | | | | | | |
| **Sum of All Plays**** | | **4,152** | **29,041** | **77,357** | **1,895** | **12,381** | **31,841** | **421** | **2,999** | **8,234** | **8.070** | **57.140** | **156.879** | **2.246** | **19.632** | **52.648** | **2,317** | **15,380** | **40,075** | **10.316** | **76.772** | **209.527** |

** Free gas, occurring as gas caps associated with oil and as oil-free gas pools (non-associated gas).*

*** Values as reported out of Basin Level Analysis-Geologic Scenario aggregation module in GRASP, "Volume Ordered" aggregation option. Total liquids and total gas values were obtained by summing resource values for means and fractiles of component commodities. Play resource values are rounded and may not sum to totals reported from basin aggregation.*

**** Results for play 7 do not exclude discovered gas and condensate resources at Burger gas pool (14.038 Tcfg + 724 Mmbbl-condensate). Use of the GRASP discovery process "Match" modules to remove Burger discovered resources reduces the mean BOE for play 7 to 5,799 Mmbbl-oe, the mean total liquids to 3,573 Mmbbl and the mean total gas to 12.506 Tcf.*

*BOE, total energy, in millions of barrels (5,620 cubic feet of gas per barrel of oil, energy-equivalent); Mmbbl, millions of barrels of oil or liquids; Tcfg, trillions of cubic feet of natural gas*

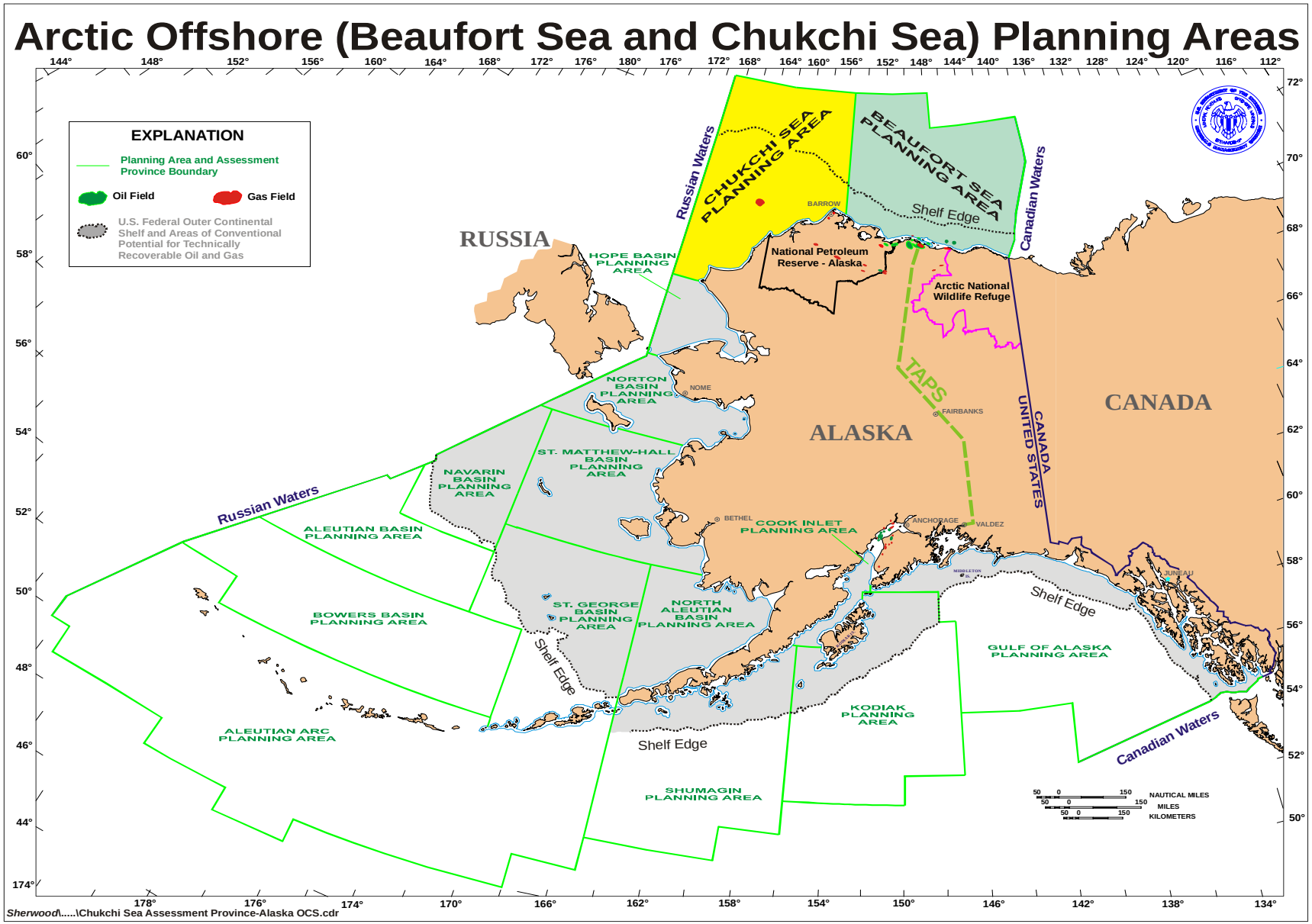



**Figure 1**. Locations of Beaufort Sea and Chukchi Sea Planning Areas and shelf-area assessment provinces.

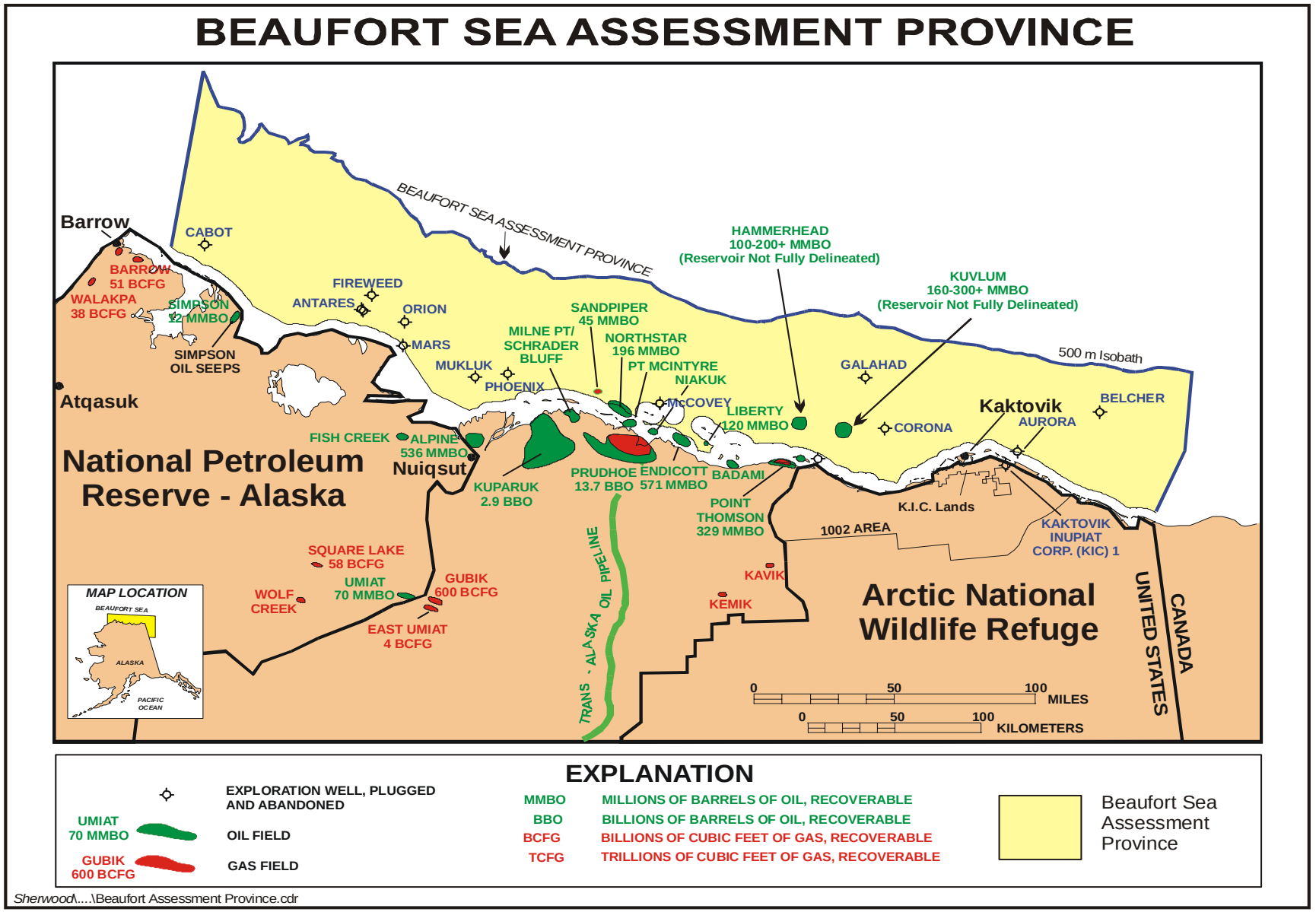



**Figure 2.** Location of Beaufort Sea assessment province, with discovered fields and northern Alaska oil production infrastructure.

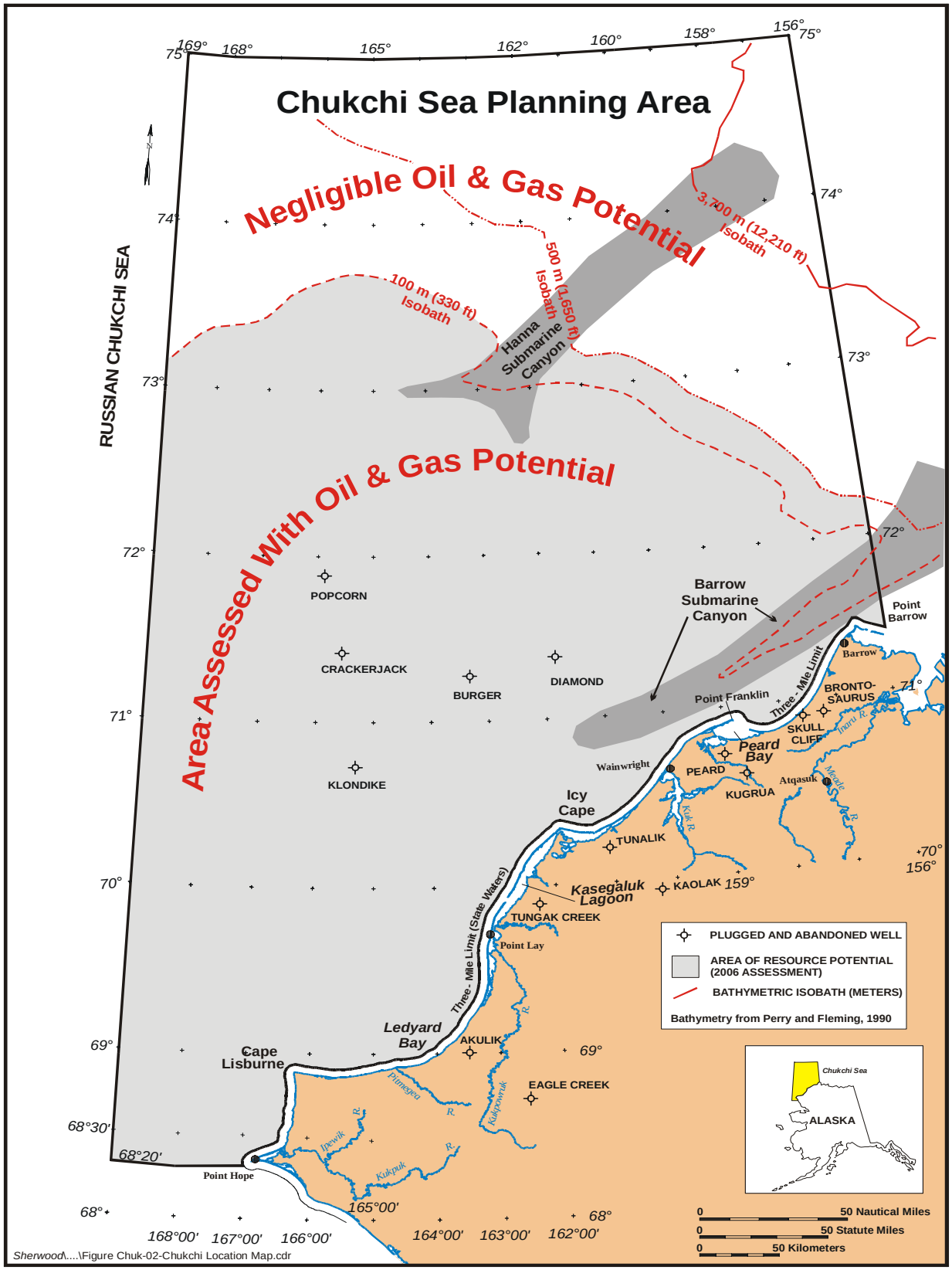



**Figure 3**. Location of continental shelf area within the Chukchi Sea Planning Area. The shelf area was assessed as offering potential for technically recoverable oil and gas in the 2006 assessment.

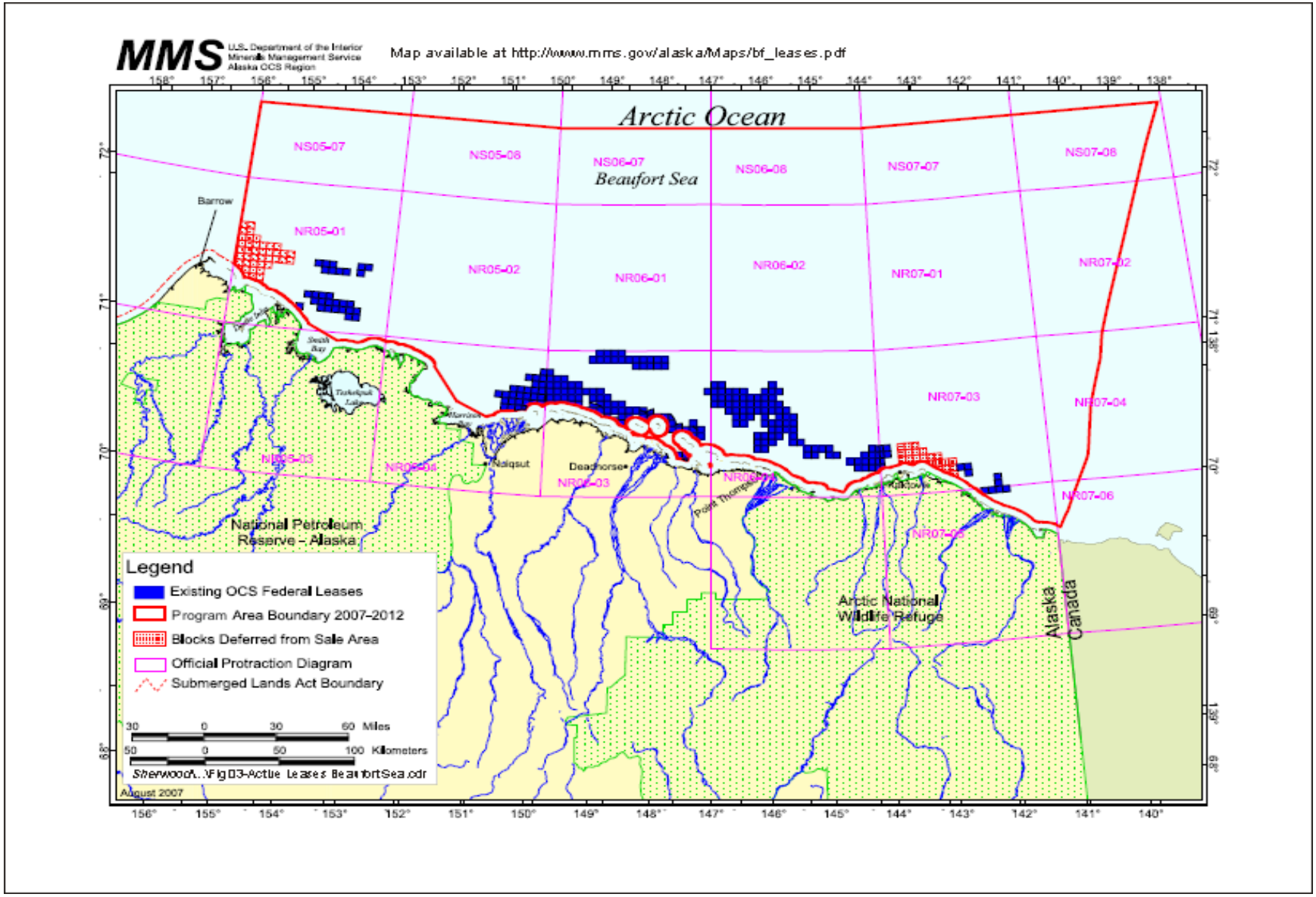



**Figure 4.** Leases active in the Beaufort Sea Planning Area as of August 2007. Original file of map available for download in pdf format at http://www.mms.gov/alaska/Maps/bf_leases.pdf.

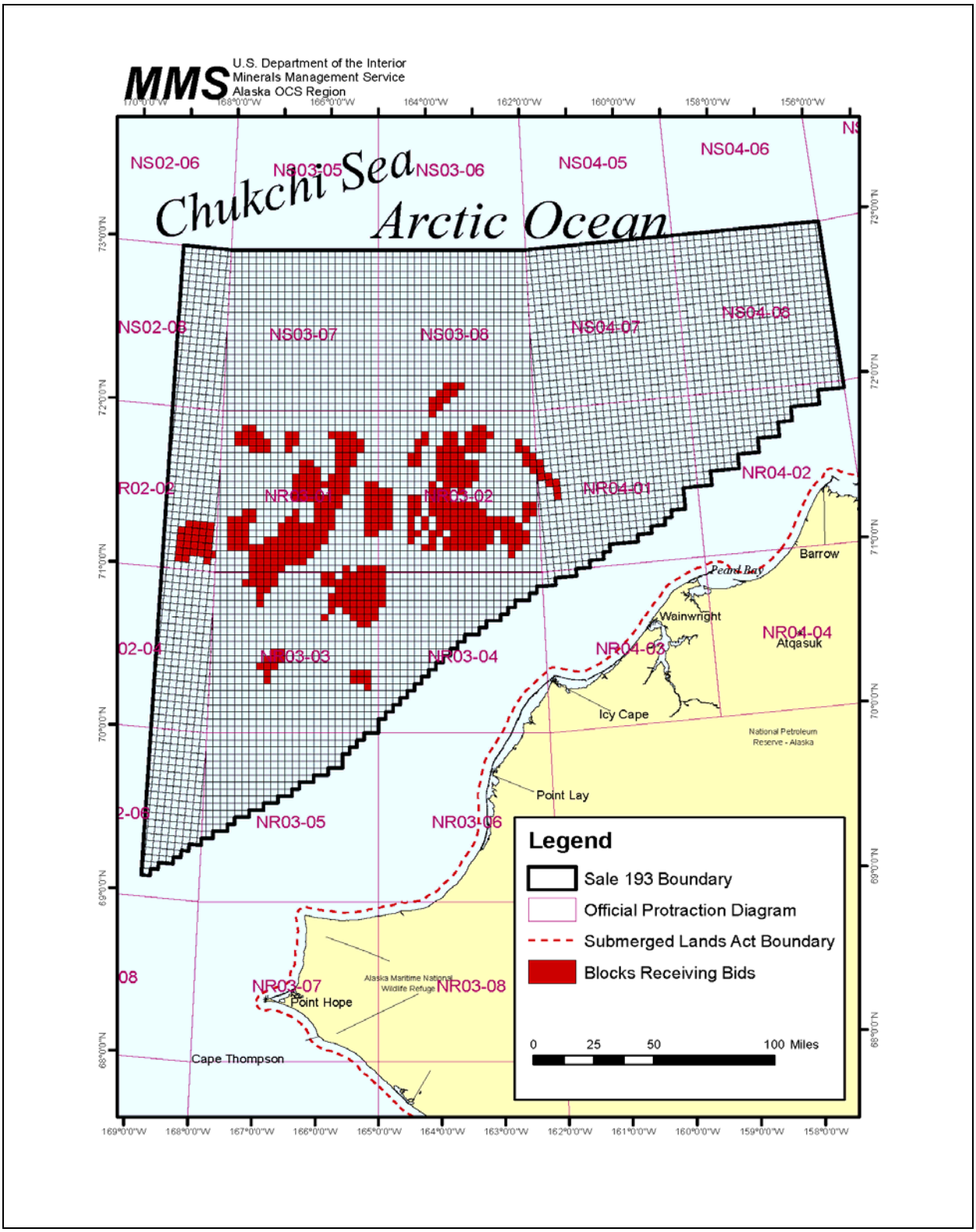



**Figure 5.** Map of blocks receiving bids in Chukchi Sea Sale 196 (February 6, 2008). Original file of map available for download in pdf format at http://www.mms.gov/alaska/cproject/Chukchi193/193Saleday/Sale_193_blx.pdf.

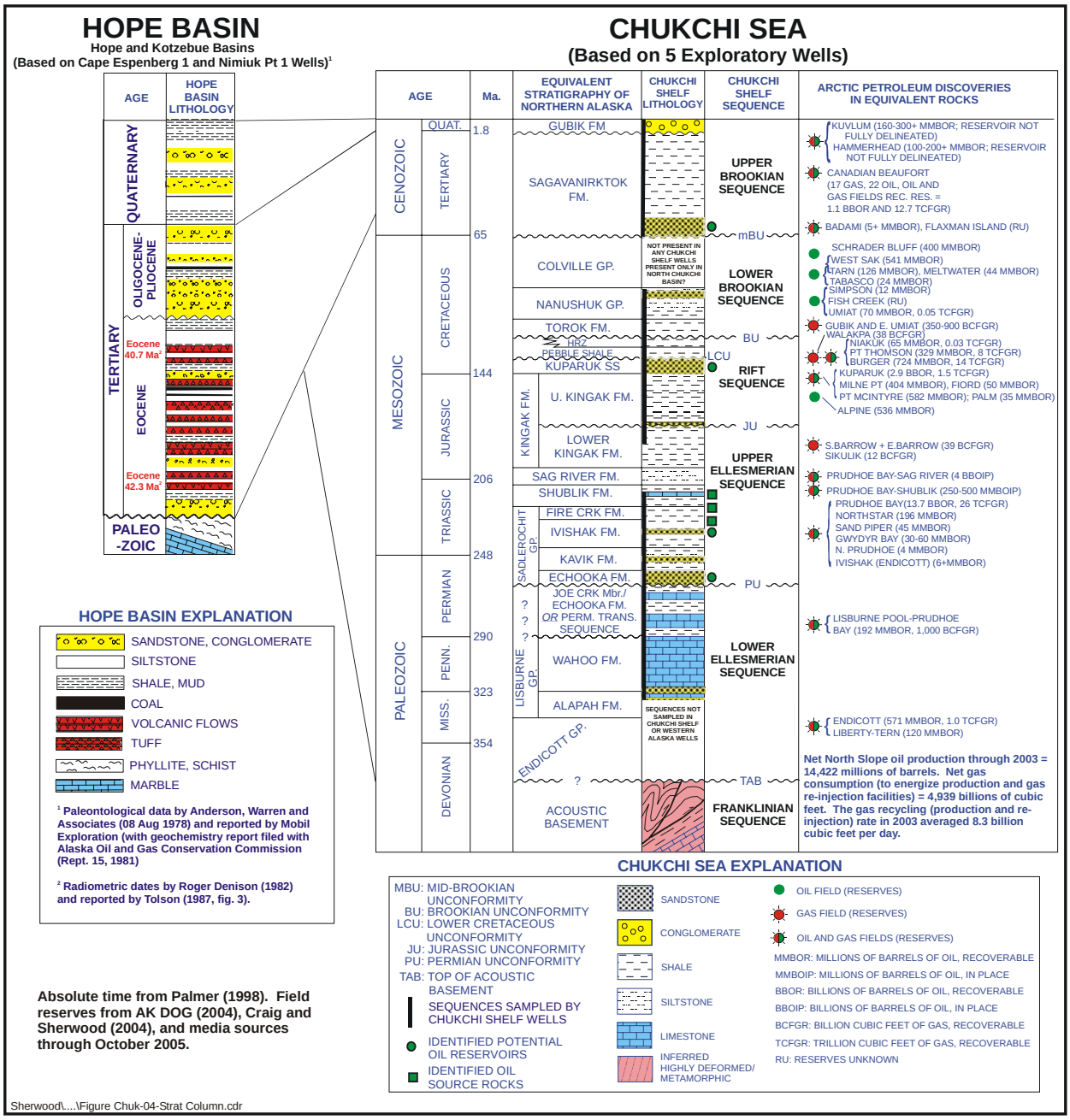



**Figure 6**. Stratigraphic columns for Hope basin and Chukchi shelf basins north of the Herald arch.

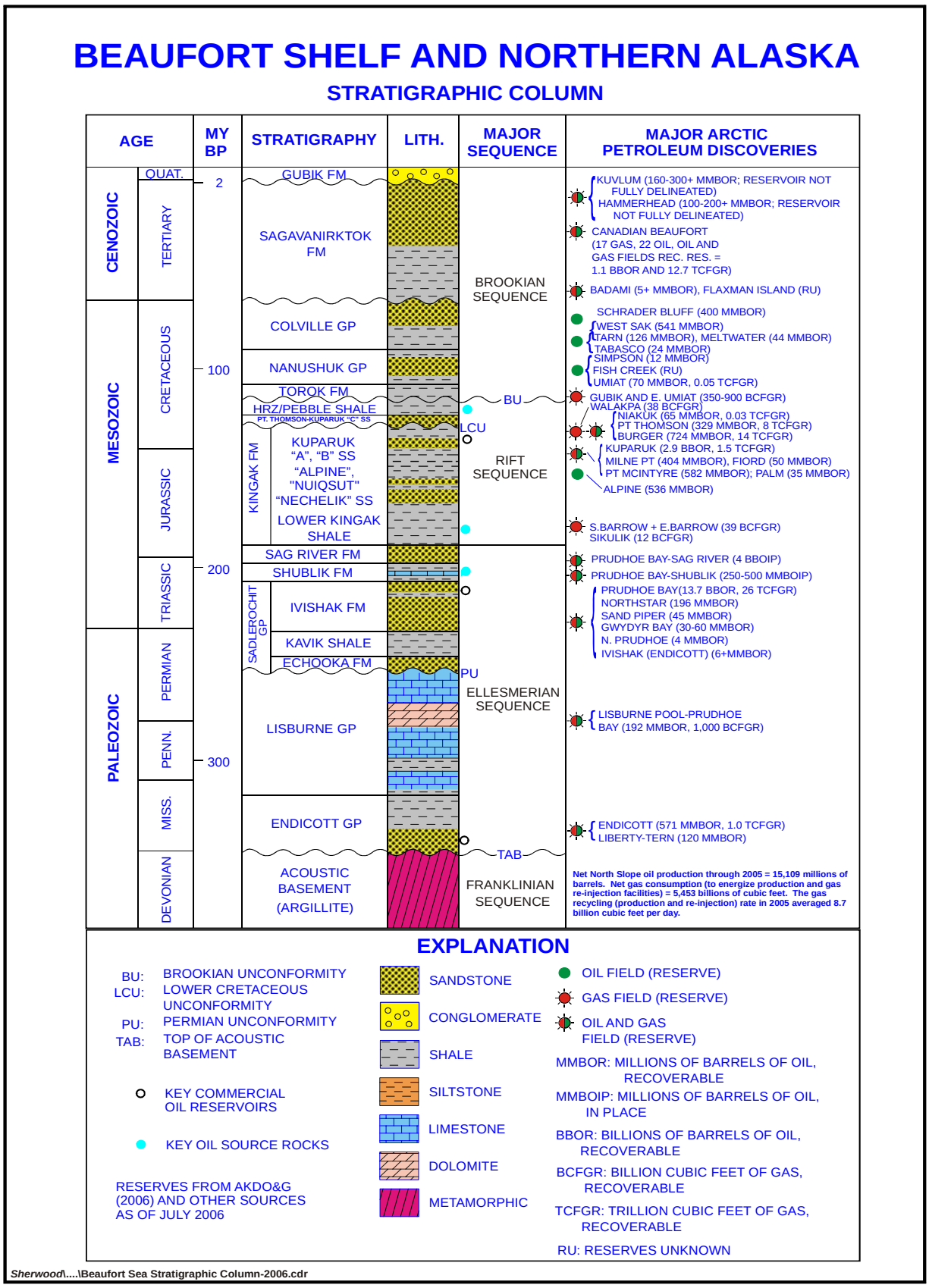



**Figure 7.** Stratigraphic column for Beaufort Sea Planning Area and northern Alaska.

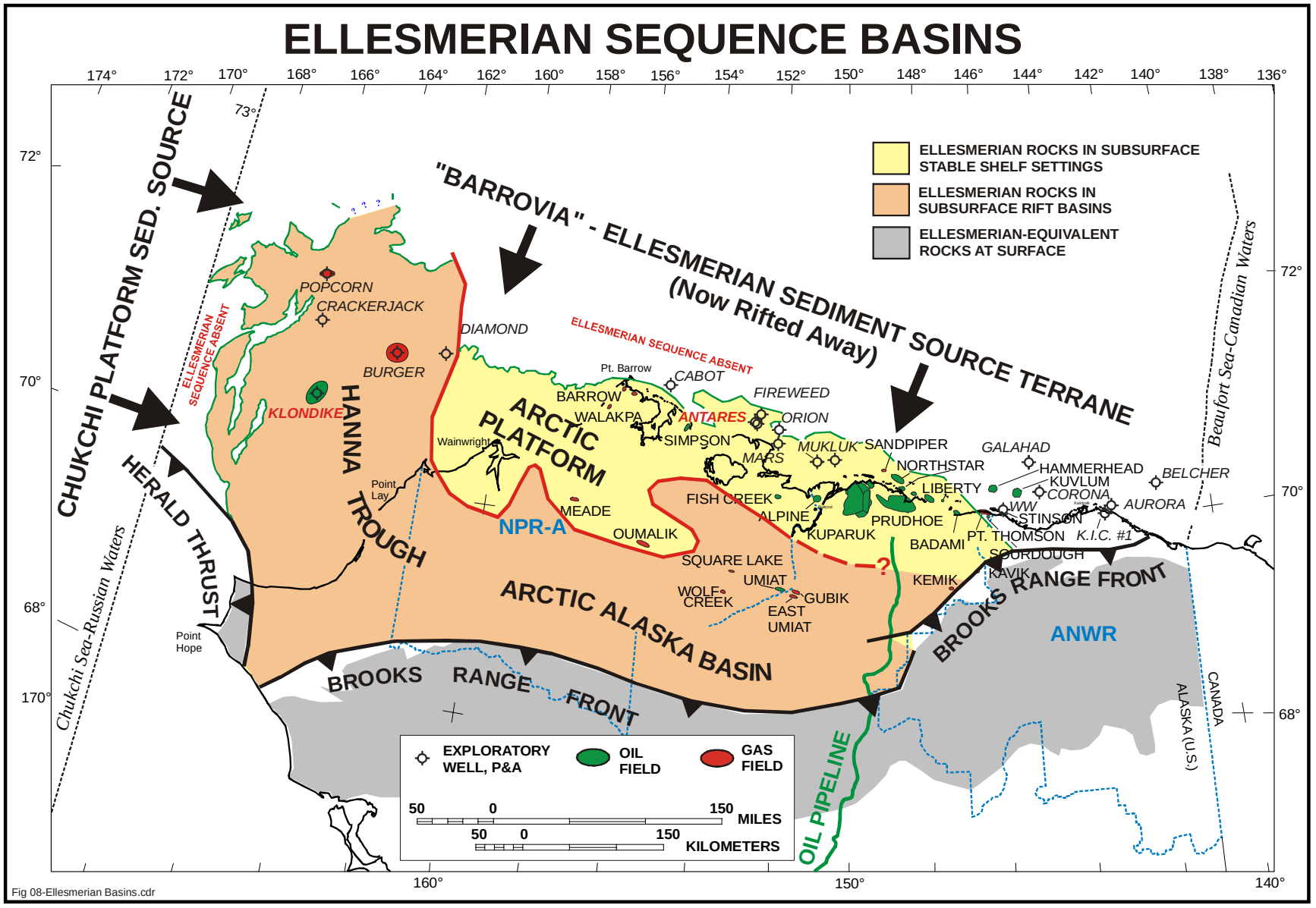



**Figure 8**. Ellesmerian sequence depositional systems and tectonic setting, Arctic Alaska and Arctic offshore.

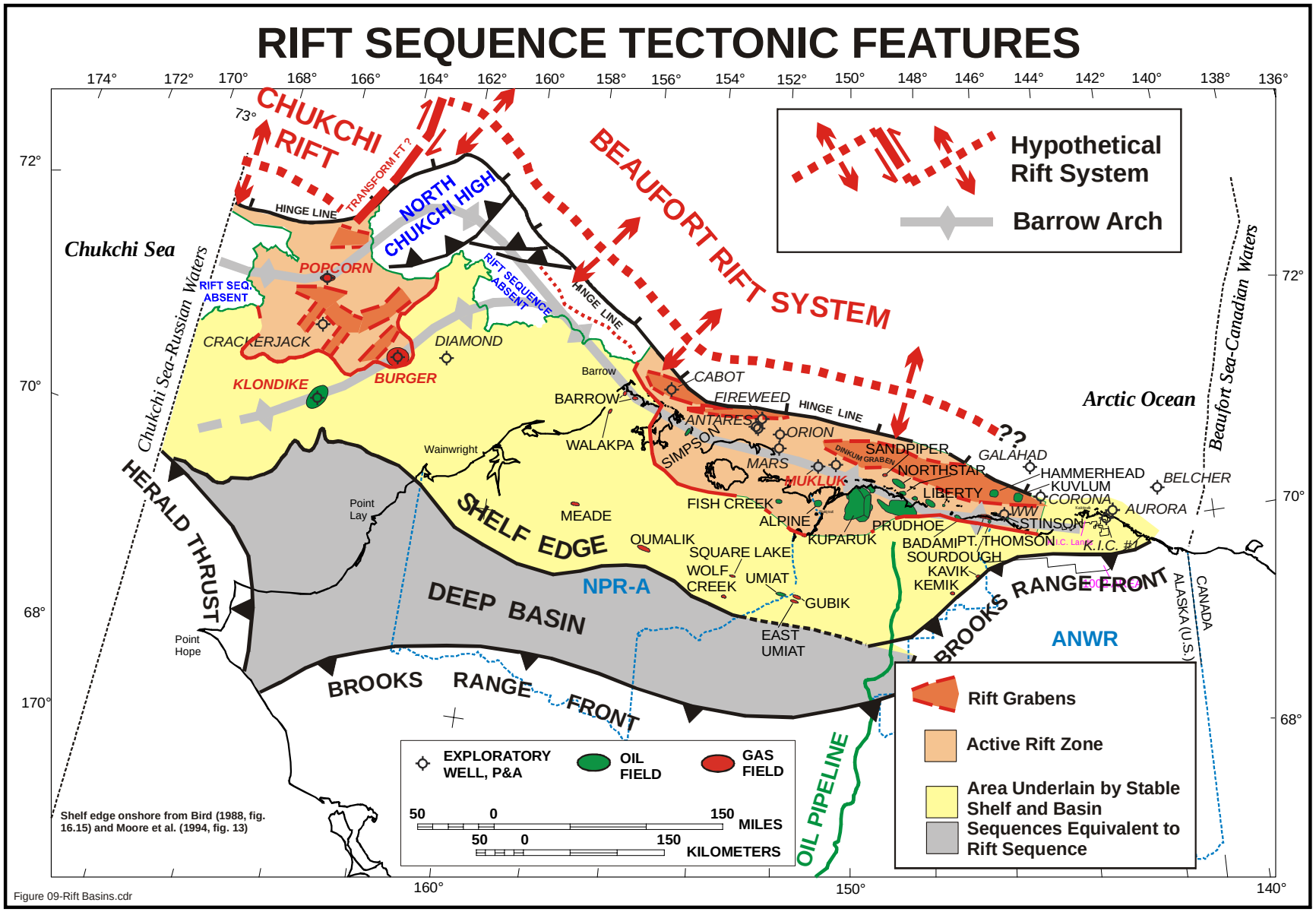



**Figure 9**. Rift sequence depositional systems and tectonic setting, Arctic Alaska and Arctic offshore.

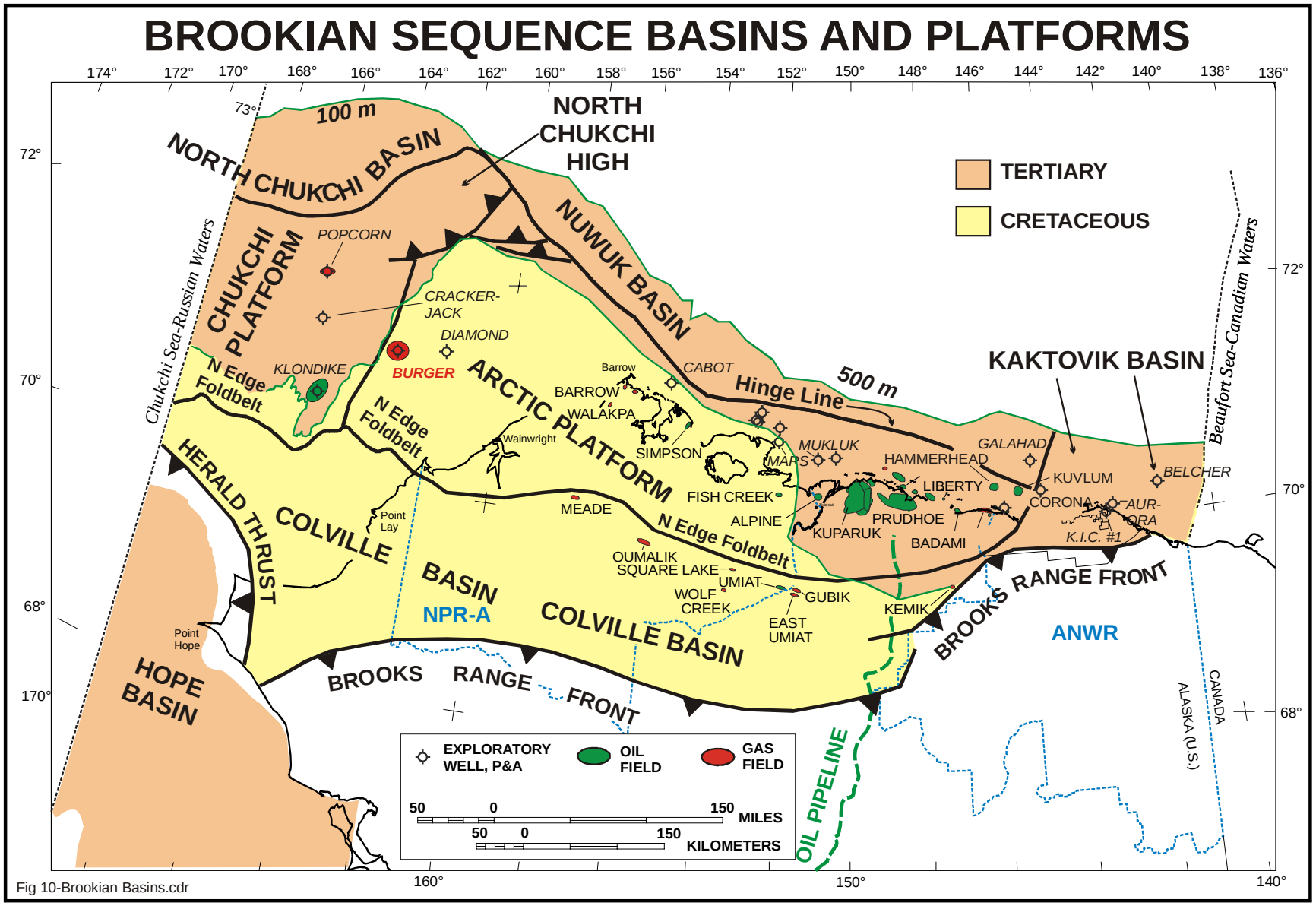



**Figure 10**. Brookian sequence depositional systems and tectonic setting, Arctic Alaska and Arctic offshore.

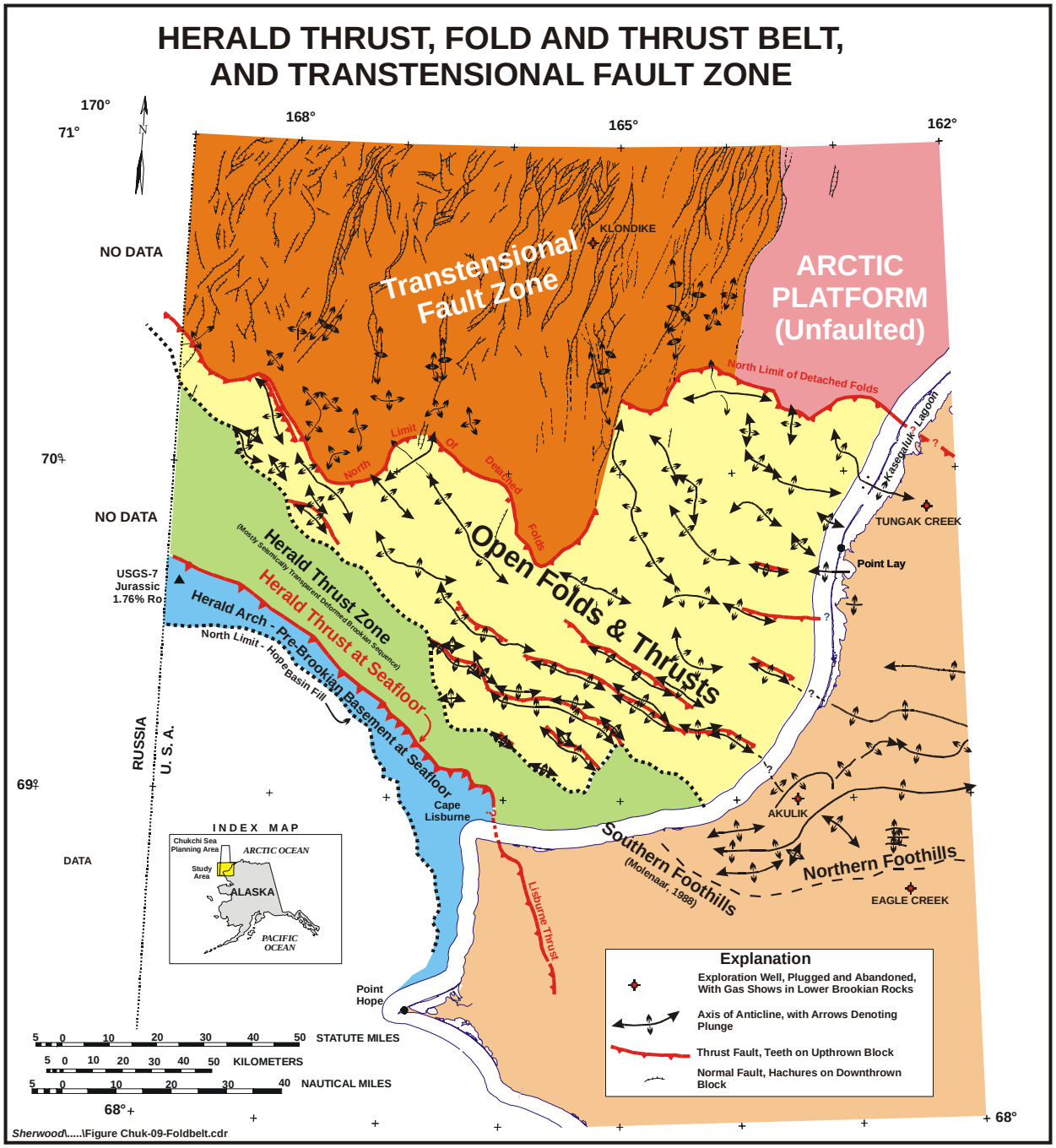



**Figure 11**. Map of structural provinces affecting lower Brookian sequence in southern part of Chukchi Sea Planning Area.

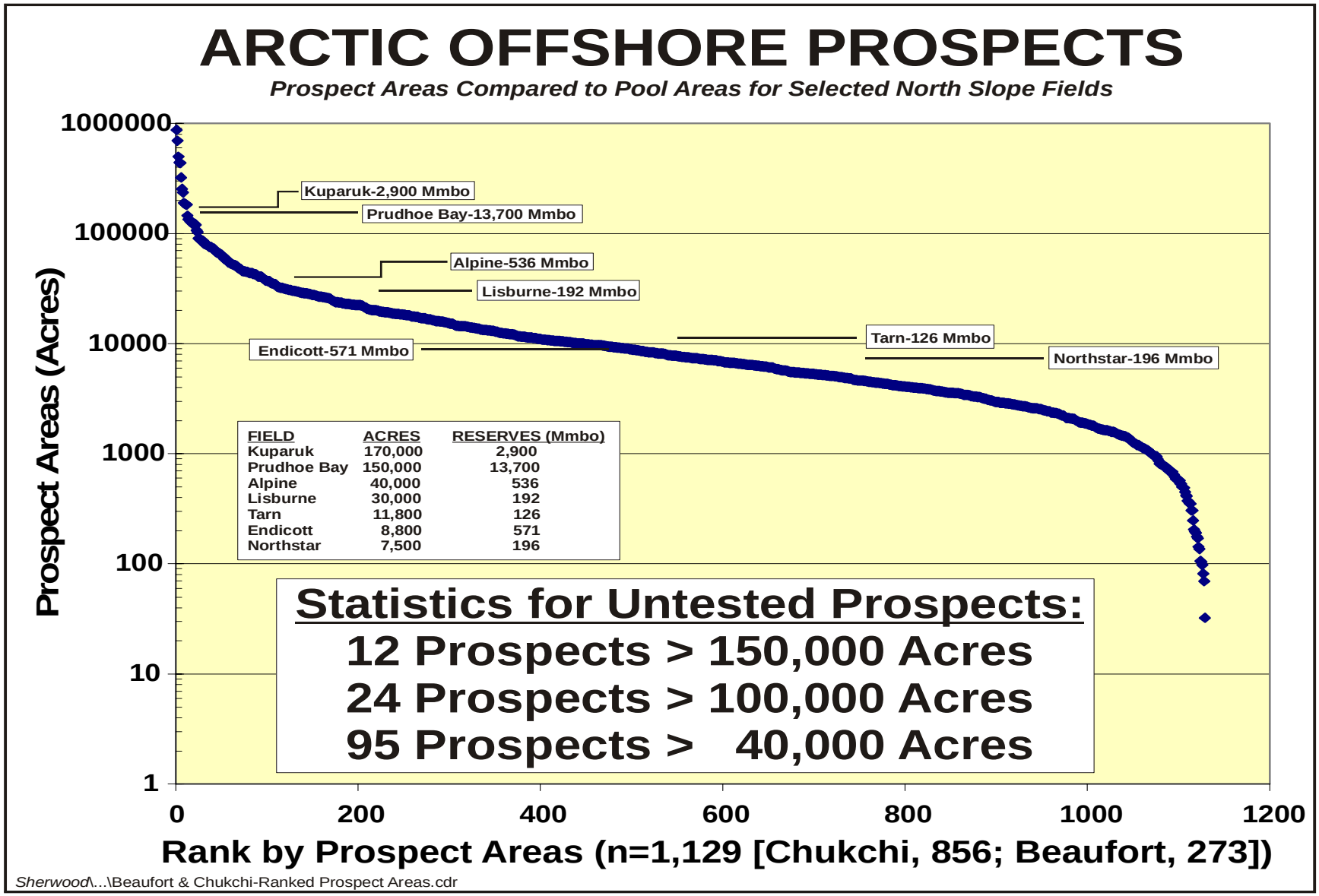



**Figure 12**. Rank plot for areas within closure (maximum potential productive area) of prospects mapped in seismic data within the Beaufort Sea and Chukchi Sea Planning Areas, with comparisons to productive areas of Prudhoe Bay and other producing fields in northern Alaska.

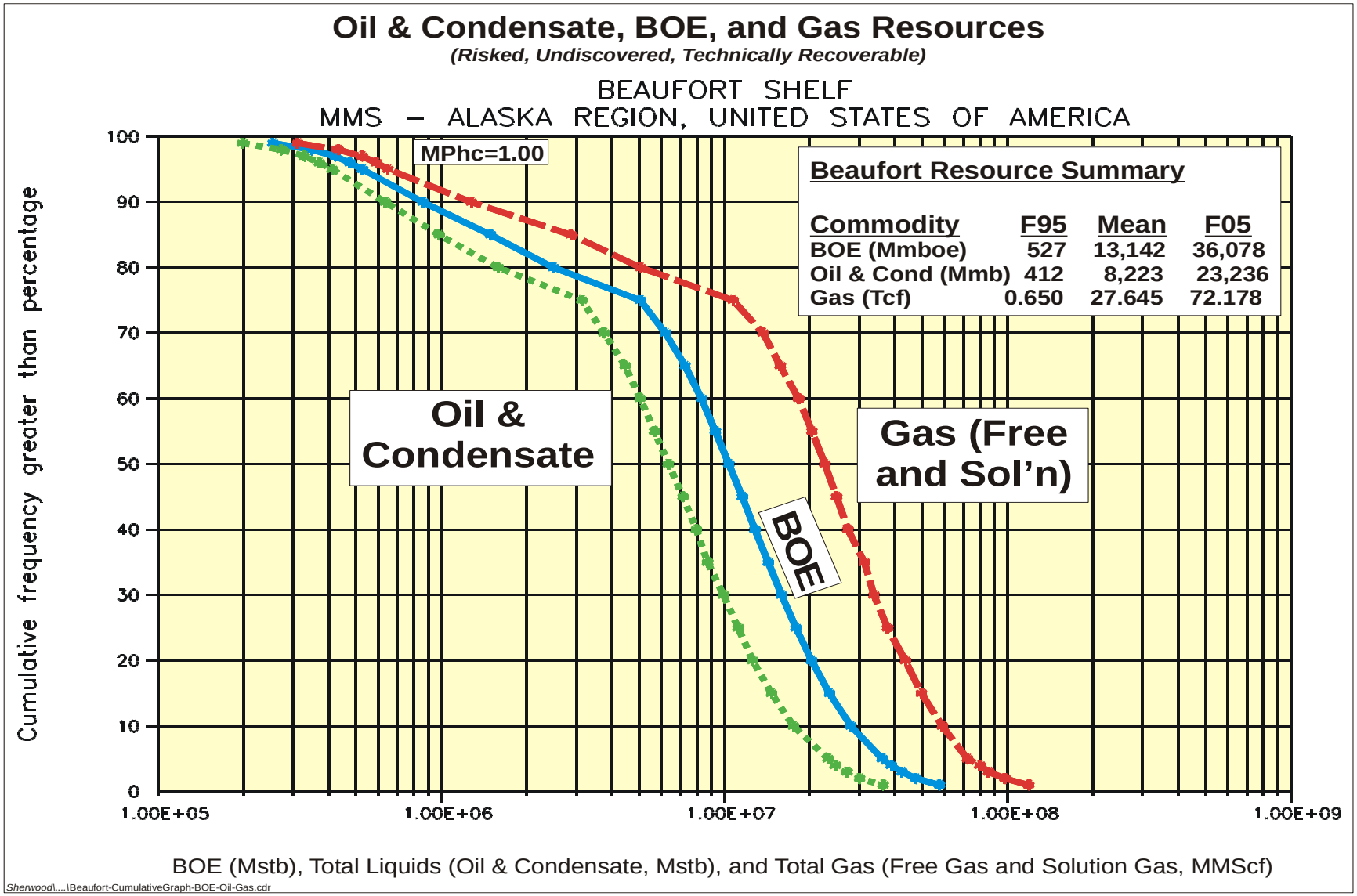
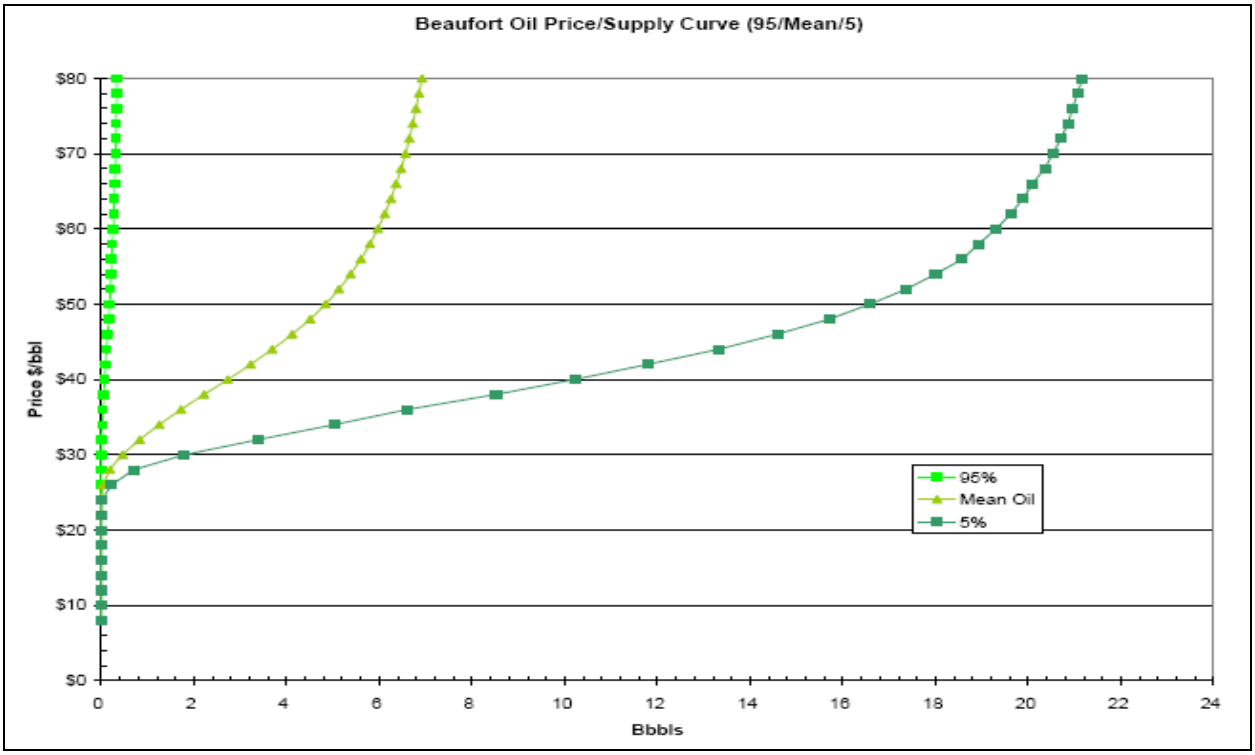



**Figure 13**. Cumulative probability plot for undiscovered, technically recoverable oil and gas resources for Beaufort Sea Planning Area and assessment province, 2006 assessment.

A.



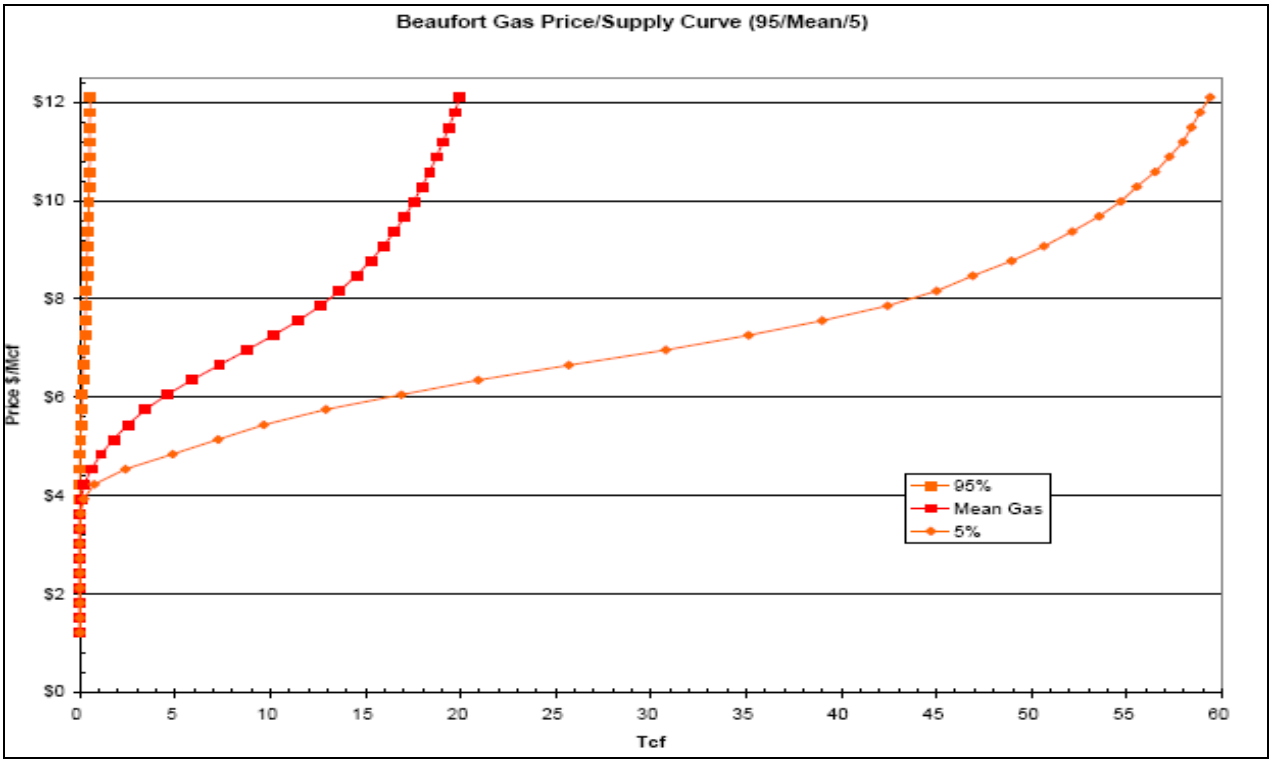




**Figure 14.** Range of economically recoverable oil (A) and gas (B) undiscovered resources versus market price for the Beaufort Sea Planning Area for low (95% chance), mean, and high (5% chance) resource cases.

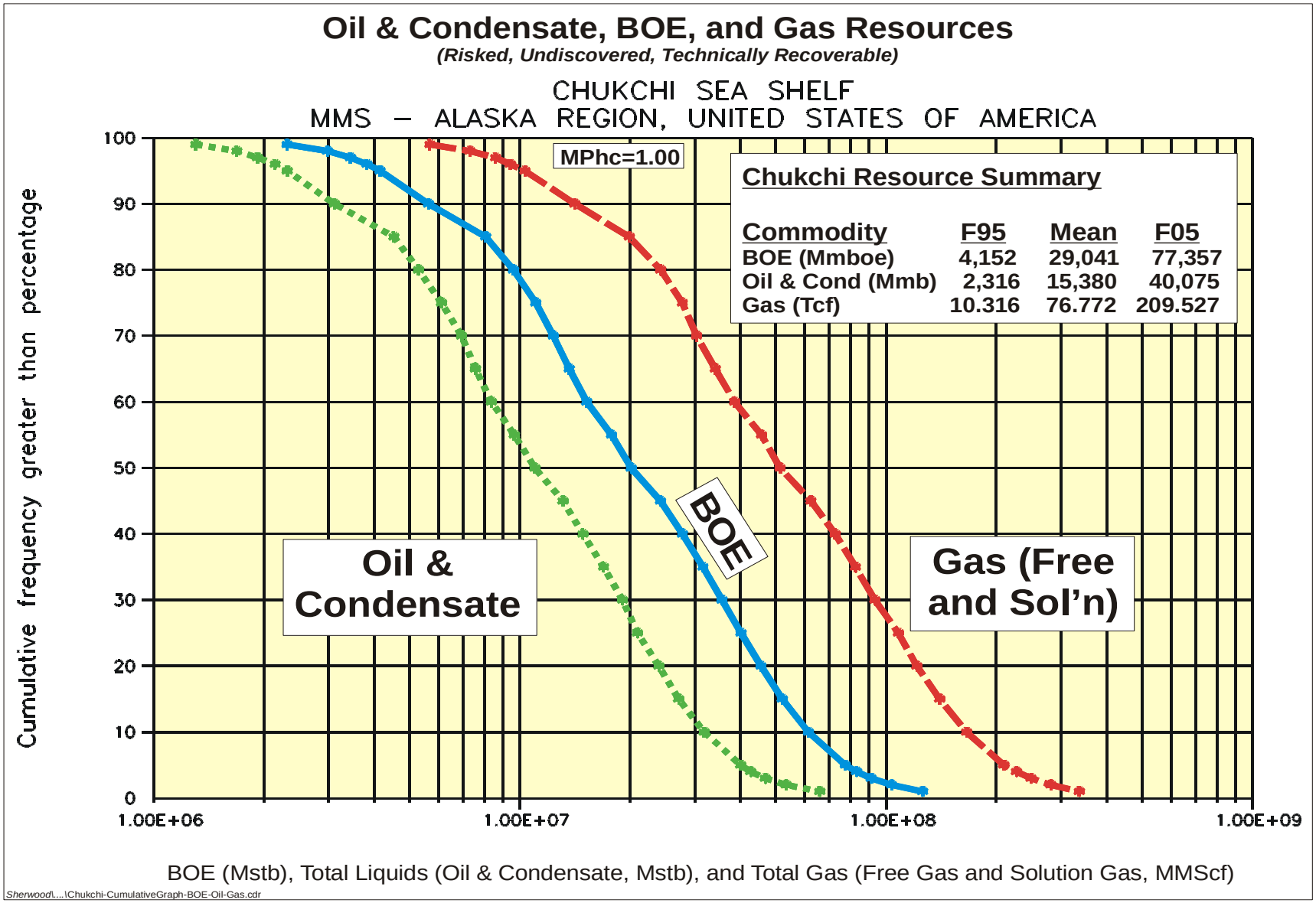
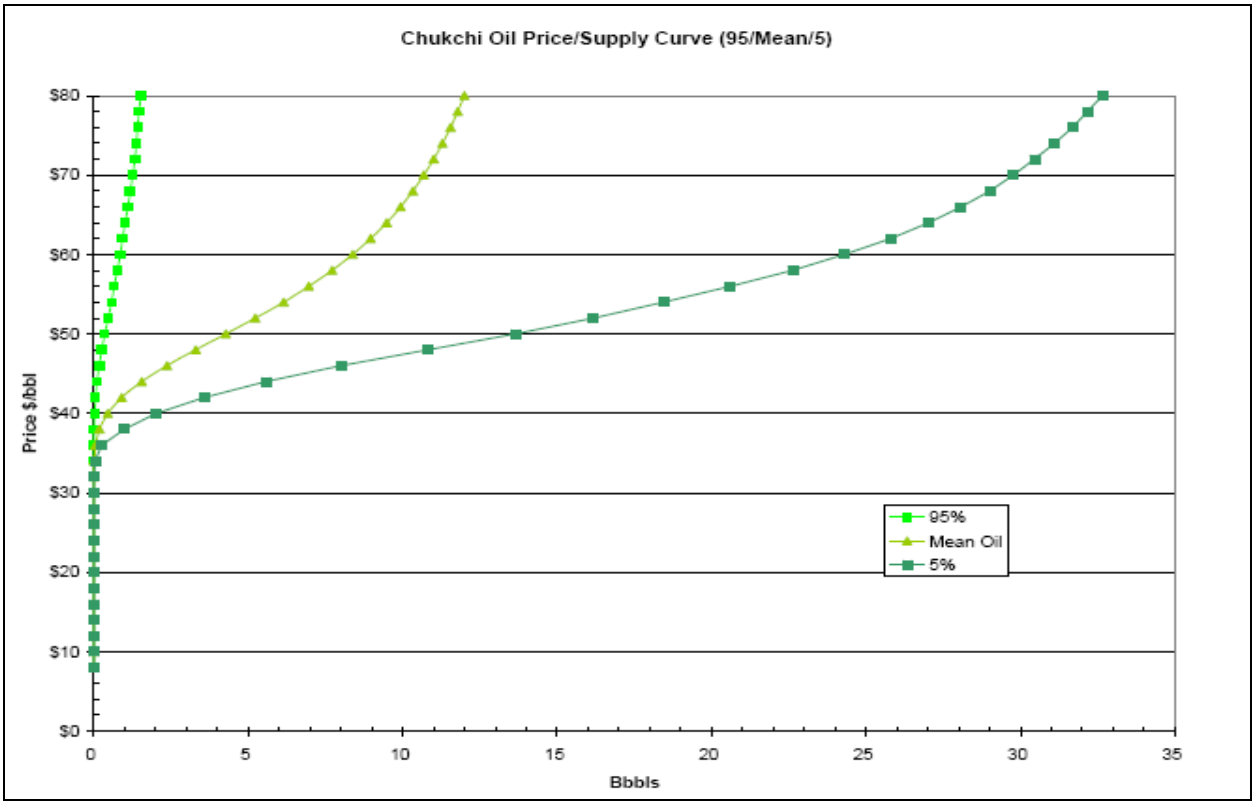



**Figure 15**. Cumulative probability plot for undiscovered, technically recoverable oil and gas resources for Chukchi Sea Planning Area and assessment province, 2006 assessment.

A




B

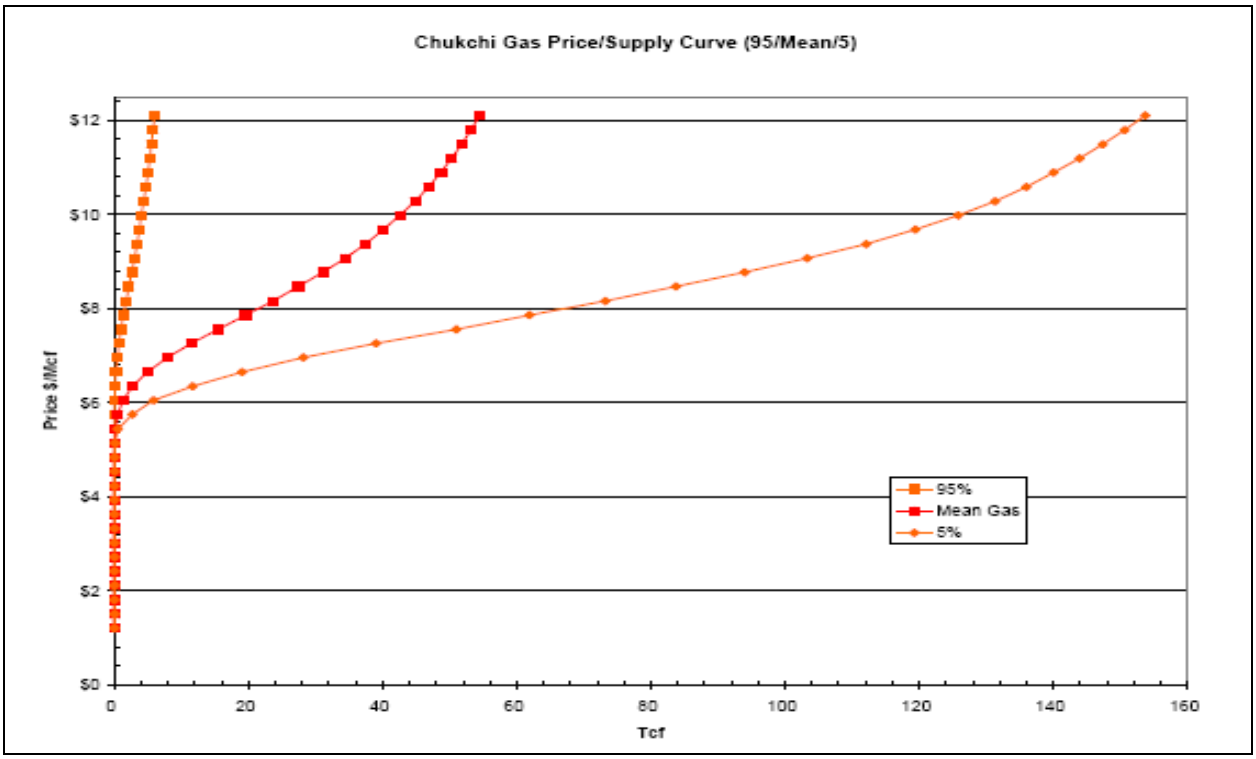



**Figure 16.** Range of economically recoverable oil (A) and gas (B) undiscovered resources versus market price for the Chukchi Sea Planning Area, for low (95% chance), mean, and high (5% chance) resource cases.

# APPENDIX D

# CONDITIONAL PROBABILITY ANALYSIS OF PETROLEUM DEVELOPMENT SCENARIOS

## CONDITIONAL PROBABILITY ANALYSIS OF PETROLEUM DEVELOPMENT SCENARIOS

**Uncertain Scenarios.** The scenarios for petroleum activities that could occur as a result leasing in the Beaufort Sea and Chukchi seas are discussed in this appendix (Appendix B). The estimates that comprise these scenarios are uncertain, because they are based largely on professional judgment and not rigorous statistical data. Although predictions are part of everyday life, predictions are seldom accurate.

Because uncertainty is unavoidable, quantitative methods have been developed to qualify estimates. *Probability* defines the likelihood that an event will occur. If the event occurs, the possible outcomes are bracketed by a *range of values*. When conditions are uncertain, it is misleading to discuss estimated values without placing them in some context to probability.

Many of the petroleum activity and infrastructure estimates discussed in Appendix B were defined using a range of values. In this section, we discuss a methodology to define probabilities associated with different scenarios.

**Conditional Probability Modeling.** Decision analysis under conditions of uncertainty is widely used in business management (Howard and Matheson, 1989) and in the petroleum industry (Newendorp, 1975). Analytical software (Precision Tree in the @RISK Suite; Palisades, 1997) serves as a platform to illustrate the array of possible scenarios and their associated probabilities. The model is displayed as a tree-like diagram where probabilities throughout the tree are adjusted according to Bayes' Theorem (Palisade, 1997). Ultimately, the likelihood of a particular result is conditional on the success of the preceding events.

The present analysis evaluates the outcomes of events, so we call the diagram an *event tree.* The tree includes a sequence of events (nodes) followed by a number of possible outcomes (branches). The key concept of this model is that the probabilities for all of the outcomes stemming from one event must sum to 100%. The relative likelihood of each outcome is reflected by its probability. The outcomes (branches) stemming from events lead to other events and proceed to numerous end results. This model is a good example of "a picture is worth a thousand words," because a complicated set of events/outcomes is simply illustrated with its corresponding set of conditional probabilities.

The following discussion uses a few simple definitions. *Chance* is defined as the likelihood of occurrence and is used for input parameters with values given as percentages (100% chance is equal to certainty). *Probability* also represents the likelihood of occurrence, but it is used for calculated outputs given as decimal fractions (1.0 probability is equal to certainty). Risk is used as the complement function of either chance or probability, but it also implies a negative consequence. For example, an 80% "dry hole risk" (failed exploration well) implies that the chance of success (discovery) is 20%. The cost of the well (millions of dollars) is the negative consequence.

**Steps from Leasing to Production.** The best way to understand conditional analysis is to construct an event tree and follow the logic for probabilities associated with the events and outcomes. Figure D-1 illustrates a typical sequence of events beginning with a lease sale, proceeding through exploration, and ending with the development of a commercial oil/gas field. The assigned chances are subjective but are based on logic.

The first event in the process (leasing) indicates that a company must acquire the tracts overlying a possible oil or gas field. Although a typical lease sale may offer hundreds of tracts, companies will map the area before the lease sale and analyze geologic trends to identify attractive structures (prospects) that could hold large oil/gas pools. A relatively high chance (80%) is given that companies will lease tracts on prospects that could prove to be commercial pools. The "not leased" chance is relatively low (20%), representing situations where new geologic concepts are needed to identify prospects or that available data are inadequate to identify the prospects.

In the next event (drilling), leased prospects must be tested by drilling to prove the occurrence of oil/gas pools. Because offshore exploration wells are very expensive ($10-$70 million each), companies will be quite selective and usually do not drill most of the leases they acquire. Accordingly, we assign only a 10% chance that the prospect containing the commercial oil/gas pool will be drilled by a limited amount of exploration wells.

In the next event (discovery), data from the exploration well(s) can be used to determine if oil/gas is present in recoverable volumes and the reservoir is capable of production at acceptable rates, both of which are important in establishing commercial viability. We assume that the tracts on prospects have been high graded, so we give a relatively high chance (40%) that an oil/gas discovery is made. However, "discovery" does not necessarily mean that recoverable volumes or reservoir quality meet commercial standards, only that oil/gas is present in the well.

In the last event (development), whether a discovery proceeds to commercial development depends on many factors, including recoverable volume, reservoir performance, oil/gas prices, adequate technologies, regulatory restrictions, and corporate investment strategies, among others. In fact, most discoveries do not become producing oil/gas fields, because one or more of these factors precludes economic viability. However, in this example we assume that conditions are favorable and we assign a moderate chance (33%) that the discovery will become a commercial oil/gas field.

The results of the event-tree analysis are listed on the right side of the matrix. The calculated probability that a lease sale will result in a commercial development is only 0.01056 (about 1%). Combined failure branches at the events in the sequence sum to 0.99. This illustrates that success is conditional (dependent) on the previous events, and many successful outcomes must be linked together to result in commercial development.

The Alaska OCS is considered a *frontier area*, because development has not occurred in most parts of the area. This means that the hurdles between leasing and development have not been overcome. For most of the Alaska OCS, the leasing history is not extensive enough to provide a strong basis for analysis, but the Beaufort OCS has the most extensive history. In the next example, the event tree discussed above can be modified using data from 10 Beaufort lease sales conducted from 1979-2006 (Figure D-2).

For the first event (leasing), 929 tracts were leased from the total of 15,232 tracts offered in the 10 lease sales. If the tracts were randomly selected for leasing (not high graded by mapping and geologic analysis), the chance of a particular tract being leased is reflected by the fraction of leased/offered (929/15,232), or 6.1%.

For the second event (drilling), 31 exploration wells were drilled to test the 929 tracts leased. The fraction of tracts drilled (31/929, or 3.3%) is used to define the chance that the tract with the commercial oil/gas field would be tested.

In the next event (discovery), 9 of the 31 wells in the Beaufort OCS were confirmed as having oil/gas in potentially paying quantities. These wells qualify as official discoveries. The fraction of discoveries to total wells (9/31) defines the chance of success of 29%.

In the last event (development), only one field is currently producing from Beaufort OCS tracts (Northstar), although the development of Liberty is pending. Actually, the nine producible (discovery) wells tested six different prospects. Because only one prospect has become a commercial field, we use a 1/6 ratio to define the development chance (16.7%).

Combining these conditional events results in a calculated probability of only 0.0001 (1-in-10,000 chance) that lease sales in the Beaufort have resulted in commercial production. Admittedly, this is a low-side estimate, because we assumed that activities at various events were random (not high graded). Most of the area offered for leasing (15,232 tracts) does not contain geologic prospects (for a variety of reasons). However, subsequent events are a direct indicator of industry initiative. Only 3.3% of all tracts leased were drilled, but all of the tracts presumably overlie mapped geologic prospects.

A common question is "why would companies undertake such financially risky activities with high costs and low probabilities for success"? The obvious answer is that the financial rewards for the occasional success covers the cost of the failures. The petroleum industry is composed of the largest and often most profitable companies in the world. These companies accept and manage the investment risks in difficult areas. Only a small fraction of petroleum companies have leased and explored the frontier provinces in Alaska, and the mix of companies participating in the OCS leasing program has changed through time for a number of reasons, including: geologic concepts improve with new data from previous exploration programs; each company could view the opportunities differently; higher oil/gas prices could make previously marginal discoveries economically viable; new technology could overcome previous engineering constraints; new areas could be opened for leasing and exploration; worldwide exploration opportunities constantly change. Each of these factors could give one company a perceived advantage over competing companies. For the above reasons, we expect a continuation of leasing and exploration in these frontier areas despite the investment risks.

**Probability Analysis for the Beaufort Sales.** The activities associated with the 2007-2012 lease sales in the Beaufort OCS are summarized in Table B-2. For purposes of analysis, we assume that a "typical sale" will result in the development of one to four oil fields with a combined volume of 500 million barrels (MMbbl). Two lease sales (Sale 209 and Sale 217) are scheduled 2 year apart.

An event tree (Figure D-3) is constructed to evaluate the probabilities associated with development (assumed 500 MMbbl) and failure (no development) for both sales. Input chances define the likelihood of different numbers of fields that could combine to produce the total assumed volume. We consider several related concepts when assigning the chances to the branches of the event tree. Chances are higher for the discovery and development of fewer numbers of fields, because each field could have its unique set of hurdles to overcome. A second key concept is that larger oil/gas pools are less common in nature, so they are given a lower chance of occurrence. They also are more likely to have been identified and tested by previous exploration efforts. In all cases, the combined chance on the success side (after subtracting the chance on the failure branch) must be allocated into branches representing 1, 2, 3, and 4 pools.

Because there have been discoveries and a limited amount of development in the offshore Beaufort, we assign a chance of 20% that leasing in sale 209 will result in one to four new fields

being developed. The individual chances assigned to the four outcome branches are low (3-7%). The highest chance is for three fields, and the lowest chance is for one large field.

The events for Sale 217 stem from the outcome branches in Sale 209. Essentially the same logic is repeated with one notable modification. The chance for success in Sale 217 is doubled, because the successful outcome branches in Sale 109 indicate that the hurdles are overcome. In other words, the combined chances for success in Sale 109 are 20%, whereas the combined chances for success in Sale 217 are 40%. The chances for individual outcome branches are doubled for consistency. If no development occurs in Sale 109, the chance for the failure branch (no development) is carried into Sale 217, because the hurdles have not been overcome.

The calculated probabilities and associated production volumes are listed as results on the right side of the event tree. The large number of possible results stemming from a common source (start the sale process) is immediately apparent. Each of these results could represent a possible scenario. In all, there are 25 individual results, each with a different number of pools, production volume and associated probability. Note that the probability of a specific result is very low (0.01), except for the "no-development" case.

It also is apparent that several branches have the same result in terms of numbers of fields or production volume, so we can combine similar results. The combined results are summarized in Table D-1. This shows that the number of fields could range from 0-8 (1-4 for each sale), and the probabilities decrease with increasing numbers of fields. By far, the highest probability (0.64) is that no development (0 fields) will occur. The lowest probability (0.0032) is when eight fields are developed. A similar trend is indicated with regard to production volume. The no-development case (0 fields) has a calculated probability of 0.64. The 1,000 MMbbl scenario (500 MMbbl produced from each sale) has a calculated probability of 0.08.

Although the input variables are subjective, the results are clear. The probabilities for development of large numbers of fields or high volumes of oil/gas are very low. The most likely case (represented by the 0.5 probability level) is that no development will occur, and postlease sale activities will continue to involve exploration activities only. The second notable point is that this analysis is very conservative with respect to the input chances of commercial success. Previous examples (Figures D-1 and D-2) indicated that typical probabilities for development in an unproven frontier area could range from 0.01-0.0001. However, the event tree constructed for Sale 209 and 217 assumed chances for development ranging from 0.20-0.40. Thus, the conditional analysis of our scenarios is optimistic (from a development standpoint) or conservative (from an environmental impact standpoint) by 1-3 orders of magnitude.

**Probability Analysis for the Chukchi Sales.** The conditional probability analysis for the Chukchi leasing program follows the same guidelines as the Beaufort lease sales, with one notable difference. The Chukchi scenario assumes that one large field (1 billion barrels) would have to be discovered and developed to "anchor" the initial infrastructure in this remote area. Additional fields could be developed only if this "anchor field" is established. For the Beaufort OCS and North Slope, this anchor field was the Prudhoe Bay field developed during the early 1970's.

Because three lease sales are scheduled in the Chukchi OCS for the 2007-2012 program, each sale has the opportunity to discover the anchor field, so the no-development branch for Sale 193 leads to another exploration opportunity in Sale 212. Likewise, the no-development branch in Sale 212 leads to a third possibility of discovering and developing the billion-barrel anchor field in Sale 221. In this analysis, the chance for discovery is not influenced by the outcome of the

previous sale. The logic is that the advantage of additional knowledge from preceding wells cannot be carried into different prospects with different geology. We assign a chance of 10% that the anchor field will be discovered and when it is not, we carry the same chance for discovery to the next sale.

Figure D-4 illustrates that although the chance for the anchor field discovery is initially 10%, after a series of exploration wells following three Chukchi lease sales the chance for commercial discovery increases to 0.271 (27%). The analysis implies that the exploration opportunities are getting "picked over" because the chance of discovery in each sale progressively decreases from 0.10 to 0.081. It is also important to note that the overall chance of failure after three wells is 0.729, which is somewhat lower than the 0.90 chance of failure after only a single exploration well. This illustrates an obvious conclusion that more wells will increase the likelihood that commercial discoveries could be made.

**Conclusions**. Conditional probability analysis is a useful tool to illustrate the complexity of possible scenarios and to calculate the probability of scenarios. When analyzing events under conditions of uncertainty, it is important to qualify estimates with probabilities. Otherwise, the results can be misleading. Risk also should be considered in the context of the likelihood of an undesirable event and its adverse consequence.

The analysis discussed in this section illustrates three key points:

(1) Progressing from a lease sale to commercial production requires a sequence of successful events that are dependent on the outcomes of the preceding events. Failure at any step will stop the process leading to development.
(2) Each event carries a unique set of hurdles and risks (investment loss). The chances for success typically are much lower than the chances of failure.
(3) Leasing is a poor indication of the scale of future development, particularly in frontier areas where many technical, economic, and regulatory challenges are present.

## References

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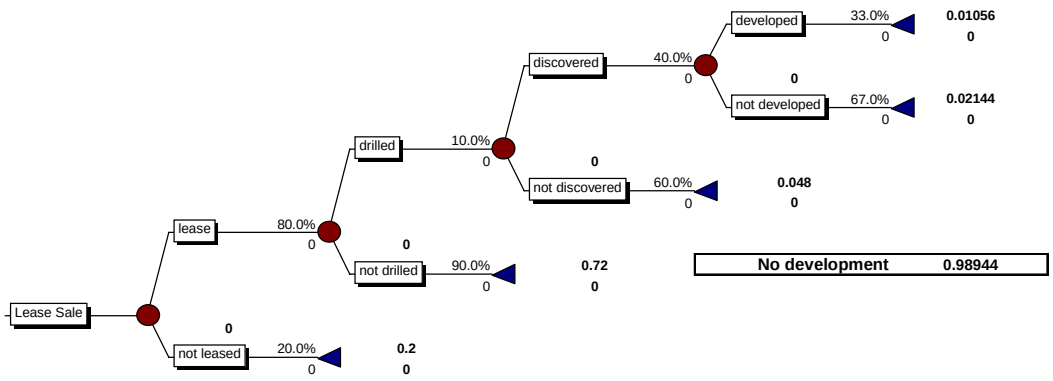
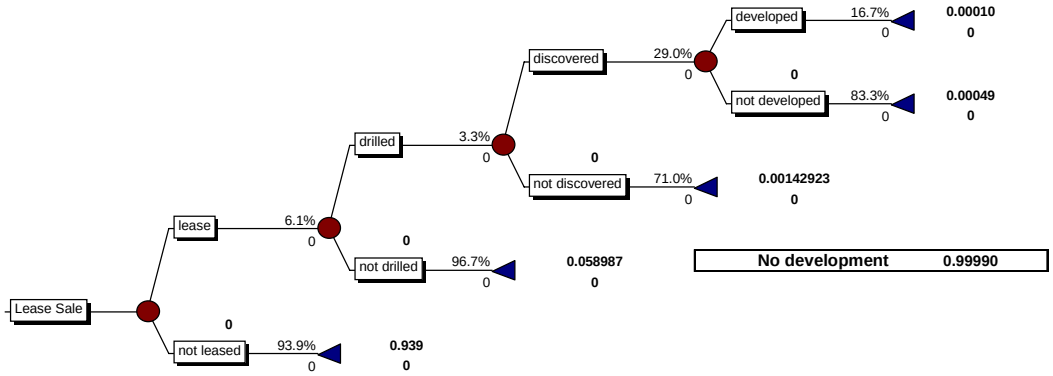
Palisade Corporation. 2000. Precision Tree, Decision Analysis Add-In for Microsoft Excel, July 2000, http://www.palisade.com

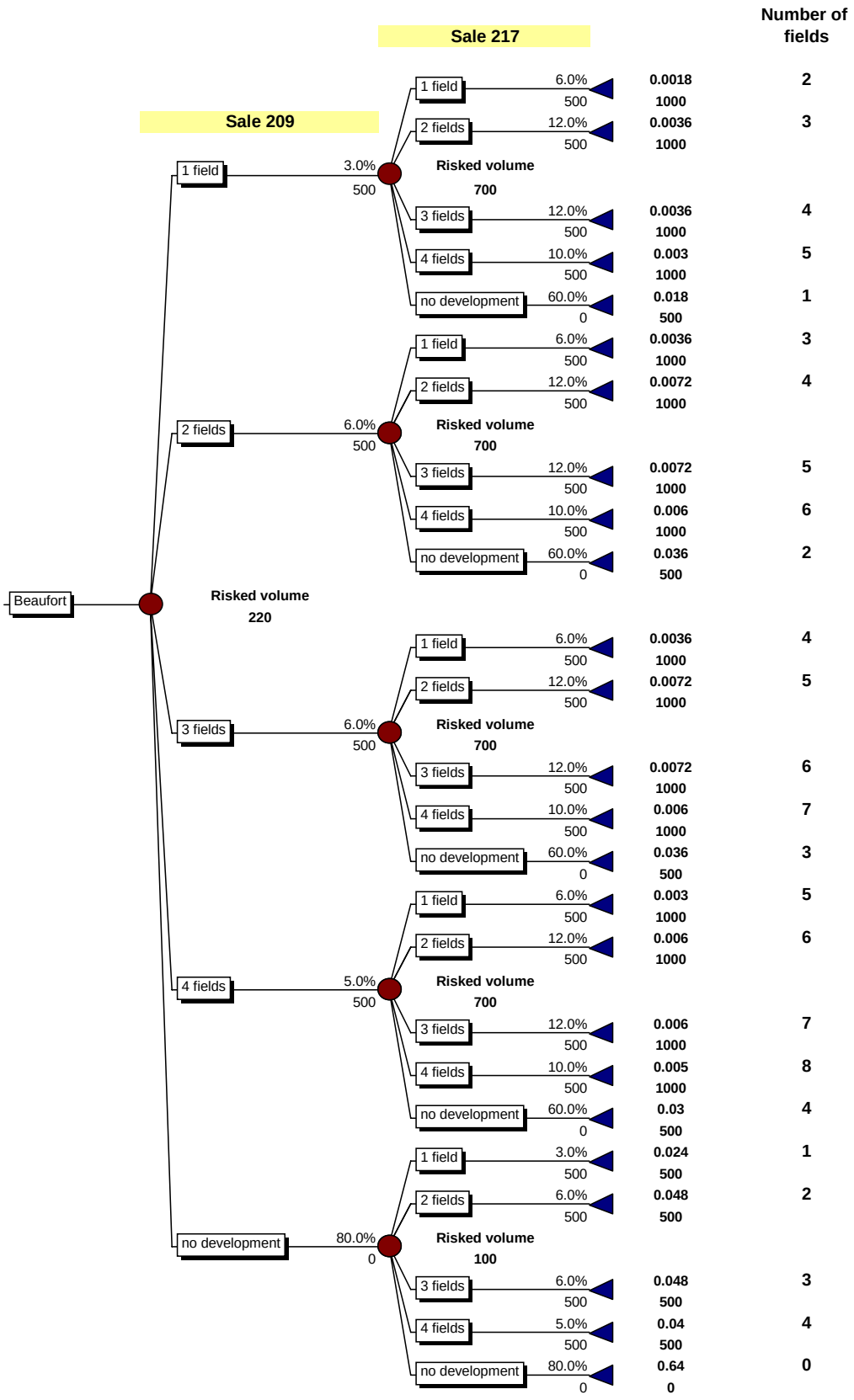
## Figure D-1. Probability Tree for a Leasing-to-Development Scenario



## Figure D-2. Probability Tree Based on Historical Data, Beaufort OCS



## Figure D-3. Conditional Probabilities for Beaufort Scenarios



## Figure D-4. Conditional Probability Analysis for Chukchi Scenarios

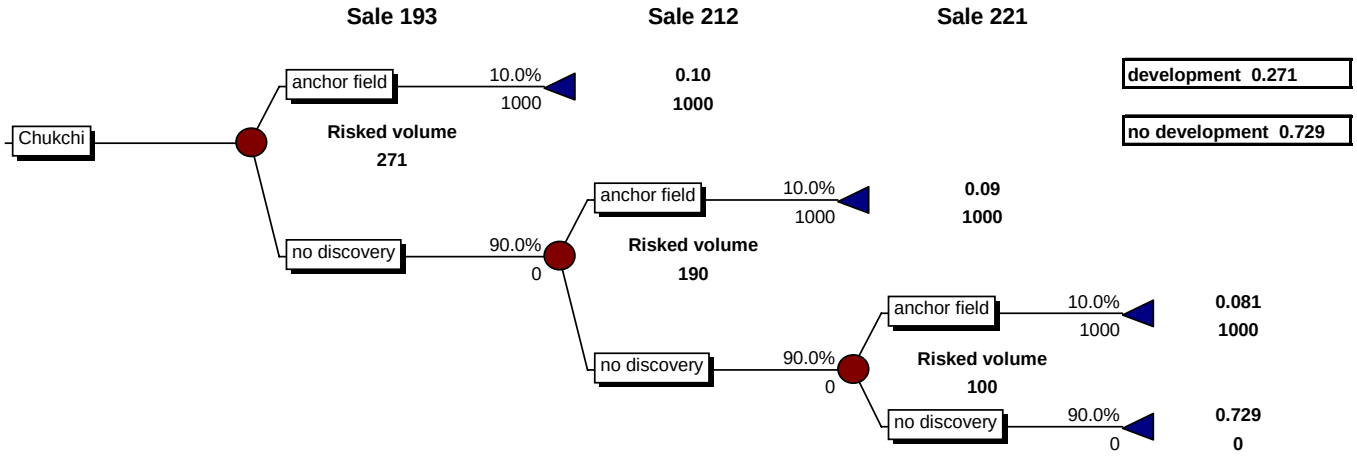


**Table D-1. Conditional Probabilities for Eight Beaufort Fields**

| total fields | combined probability |
|---|---|
| 0 | 0.6400 |
| 1 | 0.0420 |
| 2 | 0.0858 |
| 3 | 0.0912 |
| 4 | 0.0844 |
| 5 | 0.0204 |
| 6 | 0.0192 |
| 7 | 0.0120 |
| 8 | 0.0050 |
| | 1.0000 |
| 1 or more | 0.3600 |

| total volume MMbbl | combined probability |
|---|---|
| 0 | 0.6400 |
| 500 | 0.2800 |
| 1000 | 0.0800 |
| | 1.0000 |

# APPENDIX E

# SCENARIOS FOR NATURAL GAS DEVELOPMENT

# SCENARIOS FOR NATURAL GAS DEVELOPMENT

It is a widely held view by experts in the petroleum industry and Government that the northern Alaska and the adjacent offshore areas could contain large volumes of natural gas resources. Proven gas resources on State lands surrounding Prudhoe Bay are reported to be 35 trillion cubic feet (Tcf) (ADNR, 2006). Government assessments of onshore and offshore areas estimate that the mean recoverable natural gas resource in northern Alaska could total 200 Tcf (Houseknecht and Bird, 2005).

The first gas discovery in northern Alaska was the South Barrow gas field (1949), which was developed in 1950 to provide fuel for the nearby village of Barrow. Since then, numerous onshore gas discoveries have been made, ranging in time from Gubic (1951) to Spark (2000). The first gas pool discovered in the Beaufort OCS was Sandpiper (1986) (formerly Harvard). In the Chukchi OCS, the first significant gas discovery was the Burger prospect (1989). Most of the proven gas resources in northern Alaska are in the Prudhoe Bay (1967) and Point Thomson (1977) pools. Although no gas from the North Slope has been transported to market, oil-production facilities in recent years have handled approximately 8 billion cubic feet (Bcf) of natural gas per day. For comparison, this volume is equal to the average daily gas production from all fields in the Gulf of Mexico OCS (7.96 Bcfd in 2006; USDOI, MMS, Gulf of Mexico Region, 2007).

Despite the huge potential, natural gas cannot be commercially developed without a transportation system to market. It is not surprising that a number of plans have been discussed to commercialize the stranded gas resources. The following is a brief description of conceptual plans in the past, as well as an overview of the current situation as of mid-2008. It is important to remember that at some time, all of these plans appeared to be imminent. However, they all encountered engineering, economic, and political hurdles that could not be overcome. These challenges persist to the present time, and start-up of major gas export project is not expected for at least another decade.

**Alaska Natural Gas Transportation System (ANGTS).** The ANGTS plan was initiated in the mid-1970s to construct a 2,100 mile (mi) gas pipeline from Alaska to Alberta, Canada, where a system of distribution pipelines would feed into U.S. markets. Numerous permits, rights-of-way, and approvals were obtained, including a treaty between the U.S. and Canada in 1977. Although the "Pre-Build" distribution pipelines in Canada were constructed and have been operating for decades, construction of the Alaska segment of the pipeline was never started. Rising costs (estimated at $23 billion in 1982) and falling gas prices (below $3.00/million cubic feet [Mcf]) made the project nonviable. At that time, there also was a concern that major gas production would negatively affect ultimate oil recovery, with oil being the more valuable commodity at the time. To efficiently produce the North Slope oil fields, gas is reinjected to maintain reservoir pressure and as fuel for facilities. This means that full-scale gas production for export would have to be delayed until the North Slope oil fields are depleted. Although the ANGTS project was never officially terminated, work on the project declined steadily through 1980s.

This project was resurrected in 2007 when the Alaska Gasline Inducement Act (AGIA) was passed by the State of Alaska to encourage construction of a gas pipeline to market. A number of conditions favorable to State interests were contained in the bill, and in return the successful company would gain $500 million in reimbursable funding for work leading to an Open Season and a streamlined permitting process. Six applications were submitted, and TransCanada was selected as the State-preferred company. In many ways, the TransCanada application is an update

of the ANGTS project (TransCanada was one of the original ANGTS sponsors). It includes a pipeline through Alaska to the Alberta Hub (AECO), where the existing gas distribution system will move gas through several border points to U.S. markets. The cost of the TransCanada project is estimated to be $26.8 billion in addition to $8.2 billion for a new gas treatment plant (GTP) near Prudhoe Bay. Presumably, the existing pipeline distribution system from AECO would be capable of handling the new gas supplies from Alaska. At this time (July 2008), the TransCanada pipeline application has not been fully approved by the Alaska State Legislature. If this project progresses as scheduled, it could be operational by 2018 and deliver 4.5 Bcf/day of North Slope gas to the AECO hub.

**Trans-Alaska Gas System (TAGS).** The TAGS plan was initiated in the early-1980s and variations of this project are being discussed at the present time. The original design included an 800-mi gas pipeline that would follow the TAPS corridor to Valdez, where a new liquefied natural gas (LNG) facility and marine terminal would be constructed. A fleet of LNG carriers would transport the LNG to markets in the Pacific Basin. Construction would have several phases, with costs ranging from $8-15 billion for volumes ranging from 1-2 Bcf per day. Permits and rights-of-way were obtained by Yukon Pacific, and a Final Environmental Impact Statement for the LNG facility and terminal was published by the Federal Energy Regulatory Commission (FERC) in 1995. However, financing and other commitments for shipping and LNG sales could not be finalized, so the Yukon Pacific plan became dormant.

Updated versions of TAGS were reintroduced in the late 1990's, with several initiatives by the State of Alaska to promote an "all Alaska" gas-export project. These plans were similar to the TAGS project, including a gas pipeline across Alaska to an LNG-export facility on the southern coast (commonly in Valdez). The Stranded Gas Act was signed in 1998 to streamline the permitting process for a gas pipeline across Alaska. In 1999, the Alaska Gasline Port Authority was formed as a consortium of municipalities along the existing TAPS route and began to promote the pipeline with favorable tax treatment and streamlined permitting. In 2001, the Alaska Natural Gas Development Authority was created to coordinate any State gas-transportation project. All of these entities exist today and continue to actively work on conceptual gas projects involving LNG export.

**Alaska Gas System (AGS).** In the late 1990s, the AGS pipeline plan was initiated by the "Big-3" producer group (British Petroleum, ExxonMobil, and ConocoPhillips). These companies reportedly have spent more than $125 million on feasibility studies to-date. Several aspects of the plan are similar to the past ANGTS proposal, but there are some notable differences. The AGS pipeline would be large diameter (52 inches), high pressure (2500 psi), dense-phase (contains gas-liquids) "bullet line" to the U.S. Midwest. Thus, it would by-pass the AECO hub in Canada and deliver gas directly to U.S. Midwest markets. The cost estimates exceed $30 billion. If completed, this would be the largest and most expensive industrial project ever built in North America.

The Federal government got involved in 2004, when they passed the Alaska Natural Gas Pipeline Act that specified a "highway route" through Alaska and Canada, provided $18 billion in loan guarantees for construction costs, and established the Office of the Federal Coordinator to streamline the permit process through dozens of agencies. The AGS plan was supported by the previous State administration (Murkowski) who crafted a tentative agreement with the producer group in 2006. However, this agreement was not accepted by the current State Legislature or governor (Palin).

Although an informal application to AGIA by one producer (ConocoPhillips) not accepted, the AGS proposal was resurrected in April 2008 as the Denali pipeline project by BP and ConocoPhillips. Although details of the plan have not been presented in detail, it appears to be very similar to the AGS proposal. There is one notable exception--ExxonMobil is not involved at this time. The Denali project has started pre-construction field work along the proposed route and has pre-filed a pipeline license application with FERC.

The many similarities, differences and nuances between the TransCanada-AGIA plan and the producer-sponsored Denali plan are rapidly evolving at the present time (July 2008). It is likely that these two groups will continue along parallel tracks leading to an eventual Open Season (commitments to ship gas through the pipeline) and pre-construction permitting efforts. It is highly unlikely that two gas pipeline projects with similar design specifics will be constructed, so at some future time all affected parties will have to join forces. However, many of the past impediments still exist today (engineering feasibility, financing, shipping/marketing commitments, government approvals at all levels in Canada and the U.S., among others). So it is pre-mature to claim that either of these conceptual projects is imminent.

### Other Gas Projects and Related Issues

A number of other issues further complicate the picture regarding future gas projects, including:

- The State is attempting to revoke leases in the Point Thomson unit for non-performance (this gas discovery was made in the late 1970's and remains undeveloped). Proven gas resources amounting to 8 Tcf could be a key supply to the new gas pipeline project (whoever builds it).
- The State is studying other gas pipeline projects to supply in-state needs. Several tentative projects include: smaller diameter gas line from the North Slope to southcentral Alaska; a gas pipeline running north from Cook Inlet to Fairbanks; spur lines off the main TransCanada or Denali pipeline before it enters Canada; and perhaps other proposals that seem to emerge daily.

The effect of these projects and issues is unclear, but it emphasizes the future importance of new gas supplies from the North Slope to both Alaska and U.S. markets. Whether it enhances or derails the major gas export projects remains to be seen.

**Gas Scenarios for the Arctic Outer Continental Shelf (OCS).** The following discussion of gas development in the OCS areas off northern Alaska is relevant to any future gas export project because of the high resource potential in these areas. However, the scale and timing of operations from the OCS is also very uncertain. Despite the uncertainties associated with the timing and location of an onshore gas transportation system from northern Alaska, we will attempt to integrate plausible scenarios for future gas development in the offshore areas. As discussed above, no gas export plan has progressed to a real construction project, so we are in no position to make firm predictions or recommendations. Our analysis of potential environmental impacts will focus on the most plausible gas development scenario because it is impractical to evaluate all of the plans that could be proposed in the future.

**Gas Development in the Beaufort OCS.** A recent petroleum assessment of the Beaufort OCS (USDOI, MMS, 2006e) estimated that the undiscovered oil resources range from 0.4-20.6 billion barrels (Bbbl), and the undiscovered gas resources range from 0.6-72.2 Tcf. The broad range of these estimates reflects the uncertainty of the assessment. Although the size and location of future commercial fields cannot be predicted with accuracy today, the proximity of prospects in the Beaufort OCS to the existing infrastructure on the North Slope suggests that future offshore development probably will use existing onshore facilities. The TAPS has been in operation since

1977 and was recertified in 2002 for 30 more years of operation. This transportation system is expected to carry all oil production from northern Alaska to outside markets in the foreseeable future.

Although different ways to transport gas from the North Slope have been discussed (ICF, Inc., 1982; Booz, Allen and Hamilton, 1983; GAO, 1983; Thomas et al., 1996; Sherwood and Craig, 2001), most of the conceptual plans involve a large-diameter gas pipeline running south from the Prudhoe Bay area. This gas pipeline would be designed to initially carry the proven gas resources in the Prudhoe area, but future gas discoveries could be handled by expanding the pipeline capacity or timing the development of new gas fields. It is likely that when a gas-pipeline project is operational, it will encourage new exploration, development, and production of natural gas throughout northern Alaska, including the Arctic OCS.

One key factor in gas development scenario for the Beaufort OCS is timing. Many conceptual plans have been discussed, but never materialized, over the past 30 years. At the present time (July 2008), the consensus is that a major gas pipeline project will not be completed before 2018. This delay might not affect offshore development, because the lead time between leasing and production startup of new fields could be 10 years. If construction begins on a gas pipeline project it would likely increase leasing and exploration activity in the OCS. Gas fields discovered within a few years could be developed to add supplies to the new pipeline soon after it is completed.

However, another timing issue could delay gas production from fields in the Beaufort OCS. Most of the discoveries and developed fields in northern Alaska have associated oil and gas reservoirs. "Associated" means that natural gas is either contained as dissolved gas in oil or in gas caps above oil zones. To efficiently recover oil and gas ("conservation of resources"), oil is produced first and associated gas is used as fuel for facilities or injected to maintain reservoir pressure. The Prudhoe Bay field has been reinjecting associated gas since 1977. In recent years, oil facilities on the North Slope have handled 8 Bcf per day of associated gas. Because gas production has no access to market, reinjected gas is considered to be stored for later recovery. Major gas production for export would be delayed until oil fields are nearly depleted, which could be 20 years after start-up.

The main factors affecting future gas development in the Beaufort OCS are listed below:

- Gas production from the Beaufort OCS is unlikely until a transportation system is constructed.
- The earliest completion of a North Slope gas pipeline is expected to be 2018.
- When a new gas pipeline is completed, there are abundant reserves of gas that could be recovered at relatively low costs through existing infrastructure. Proven and developed gas reserves could fill the new pipeline for 10-15 years after it begins operations.
- Proven, nearby gas pools (Point Thomson, Spark) are likely to be developed before more remote, higher cost, undiscovered gas pools in the OCS.
- The new gas pipeline will probably not be designed to handle the added production from very large gas fields in the Beaufort or Chukchi OCS which are undiscovered at present.
- If commercial-size discoveries in the Beaufort OCS primarily are oil reservoirs with associated gas, gas production could be delayed for several decades until the oil reserves are depleted.

These factors suggest that large-scale gas production from the Beaufort OCS is unlikely within the next 20 years.

**Gas Development in the Chukchi OCS.** A recent petroleum assessment of the Chukchi OCS (USDOI, MMS, 2006e) estimated that undiscovered oil resources range from 2.3-40.1 Bbbl, and undiscovered gas resources range from 10.3-209.5 Tcf. The broad range of estimates reflects the uncertainty of the assessment. Although no one can accurately predict the size and location of future commercial fields, two facts are apparent: (1) the Chukchi has considerably higher gas potential than the Beaufort; and (2) the Chukchi is much farther away from existing North Slope infrastructure. This suggests that other alternatives to produce natural gas in the Chukchi are worth considering.

We discuss three possible gas export strategies for the Chukchi OCS, arranged in order from the most probable to the least probable. This ranking is based on our current understanding of the geologic, engineering, economic, and political issues. The ranking is not intended to be a prediction or a recommendation, nor does it dismiss other alternatives that could be feasible in the future. We acknowledge that different strategies to commercialize stranded gas resources could be pursued by different companies. Ultimately, decisions of how and when to develop commercial gas projects will depend on the size, location and timing of discoveries. No one can accurately predict these factors today.

**1. Gas Pipeline.** Pipelines are the most cost-effective way to transport large volumes of oil or gas to market if overland routes are feasible. Many gas pipeline plans from the North Slope to markets in the U.S. have been discussed above. Any large-scale gas transportation system from the central North Slope could probably also carry future gas production from the Chukchi OCS, subject to the same constraints as discussed for the Beaufort OCS. The two key considerations are the timing of available pipeline capacity and delays in major gas off-takes from associated oil-gas fields.

Gas development in the Chukchi OCS would require a long (approximately 300-mi) overland pipeline across the National Petroleum Reserve-Alaska (NPR-A) to connect to the new gas-export system. This pipeline might be built in phases if development expands westward across NPR-A. However, gas development in the Chukchi OCS could occur sooner if large gas discoveries in the Chukchi largely support this pipeline ($3-5 billion cost). In this way, the more remote and higher cost gas resources from the Chukchi could facilitate the development of smaller gas fields stranded in NPR-A. In either case, gas development in NPR-A and the Chukchi could be vital to a future North Slope gas pipeline that could require upwards of 50 Tcf of gas reserves to fill its capacity over its design life. Proven gas resources on the North Slope are estimated to be approximately 35 Tcf, but readily available gas reserves (in existing oil field infrastructure) may be only 20 Tcf by the time a gas pipeline is operational.

If a North Slope gas pipeline is built, minimum gas reserves of perhaps 5 Tcf would be needed to justify offshore development and the overland pipeline from the Chukchi coast to the Prudhoe Bay area. Although a number of engineering, economic, and political hurdles face any new construction project, it is likely that a gas pipeline and oil pipeline would follow the same corridor. Many of the issues will be shared and, perhaps, easier to overcome. The main difference between oil and gas pipelines across NPR-A is that oil pipelines will be elevated on supports and a chilled, dense-phase gas pipeline will be buried over most of the route.

The scenario will be different whether a pipeline from the North Slope transports gas to U.S. markets or an LNG facility is built in southern Alaska. The pipeline to the U.S. is likely to carry 4-6 Bcf per day and would more easily accommodate additional OCS production than an LNG export project that is designed to handle only 1-2 Bcf per day. Large gas fields in the Chukchi could produce 1 Bcf per day from each field.

**2. Liquefied Natural Gas (LNG).** LNG is another established method to transport large volumes of natural gas over long distances, particularly when marine routes are a viable option. LNG could be an alternative export strategy if a North Slope gas pipeline is not constructed or does not have available capacity for all available gas production in an acceptable timeframe. Natural gas is processed to liquid form by chilling the gas to approximately -260° F and maintaining that state under pressure. The LNG is then transported by specialized marine tankers (or "carriers") to coastal receiving terminals, where it is regasified and distributed through pipelines. Processing losses typically are about 30% of the gas produced, in addition to small "boil-off" losses during transportation.

Several important points are relevant to the feasibility of LNG exports from the Chukchi OCS.

- LNG operations require extensive infrastructure, including gathering pipelines; a large processing facility; a marine loading terminal; a fleet of LNG tankers; and receiving terminals at market destinations. Numerous feasibility and environmental issues are associated with each of these components in the LNG delivery chain.
- Costly LNG operations require large gas reserves. For remote locations in Arctic Alaska, a gas reserve base of at lease 10 Tcf would probably be necessary. This reserve base could be contained in several large gas fields, each of which has its own commercial and regulatory issues to overcome prior to development.
- Marine transportation is problematic in the Arctic. Sea-ice conditions could inhibit tanker loadings and transits for 6 months of the year. No LNG ships have been built to handle ice conditions common in the Chukchi. Nearshore areas are relatively shallow and could be a constraint to LNG ships (loaded draft of 12 meters).
- LNG marketing factors are uncertain. Although there are large established markets for LNG in Asia (Japan is the world's largest LNG importer), there are no LNG receiving terminals on the U.S. West Coast. The Jones Act requires that U.S.-built, flagged, and crewed ships be used exclusively for deliveries between U.S. ports. There are no LNG ships in service that meet Jones Act requirements.
- OCS resources cannot be exported to foreign countries without Congressional approval. Export licenses may be difficult to obtain when there is a need for domestic gas supplies.

These factors suggest that LNG is a plausible, but less likely, strategy to export gas from the Chukchi OCS. LNG operations will face difficult economic, technical, and regulatory challenges because it is a new concept to this region. However, if a gas pipeline is not constructed from the North Slope, the gas resources in Prudhoe Bay and adjacent areas of the Beaufort OCS will remain stranded. Meanwhile, LNG operations could transport gas from the Chukchi and perhaps western NPRA to outside markets.

**3. Offshore Gas Processing and Loading.** Offshore storage and loading technology is common in many petroleum producing areas of the world. It could be feasible in the Chukchi under some circumstances. The pipeline and LNG export strategies discussed above require very large gas reserve volumes and have huge capital costs. A reserve base of 50 Tcf is needed to supply a major gas pipeline project that could cost upwards of $30 billion. Gas reserves of at least 10 Tcf could be needed to justify an LNG operation with costs of more than $10 billion. What happens if gas discoveries in the Chukchi OCS do not measure up, or the North Slope gas pipeline is not built?

A third strategy for gas development involves offshore storage, processing, and loading to marine tankers for export. This strategy could accommodate development of smaller gas reserves and could be coordinated with offshore oil development.

Bottom-founded production platforms for the Chukchi will have to be very large to resist ice forces in relatively deepwater areas (greater than 100 feet). Because of their large size, platforms could be designed with internal storage compartments to hold oil or gas. To facilitate transport, there are several ways to convert gas to a condensed form (LNG) or a liquid form (gas-to-liquids, GTL). Gas also could be transported in pressurized containment in ships as compressed natural gas.

The following are key considerations for this strategy:

- Processing and transportation equipment can be scaled to handle different production volumes, but the unit costs will increase as the volumes decrease. Higher costs will further burden already marginal (small) gas projects in this offshore area.
- Offshore loading and tanker traffic will be affected by rough seas in the open-water season (July-Nov.) and mobile sea ice over the rest of the year, even if warming trends continue. Although the consequences of accidents from gas storage and marine operations would be different than for oil, this strategy will face numerous economic, engineering, and regulatory challenges.

**The Most Likely Gas Development Scenario.** The preceding discussion suggests that no gas scenario for the Beaufort and Chukchi OCS should be considered "reasonably foreseeable." Large volumes of natural gas have been stranded for decades in northern Alaska, as many plans have been proposed and then abandoned. At the present time, projects to export natural gas from the North Slope through a pipeline are not likely to be operational until 2018. Additional delays related to available capacity in a new gas pipeline or conservation of resource (producing oil first) could extend the timeframe for gas export several more decades into the future. Interest in developing gas resources in northern Alaska is likely to be inhibited by regulatory and financial impediments facing all large projects.

If we optimistically assume that commercially-viable gas fields will eventually be identified, we believe that the current engineering, economic, and political factors favor a large-diameter, high-pressure gas pipeline from the North Slope to markets in the U.S. This pipeline project would first carry the proven gas resources in the Prudhoe Bay area and later could carry gas from new developments in NPRA, the Beaufort OCS, and the Chukchi OCS.

Our decision regarding the most likely gas scenario is not intended to be a prediction or a recommendation, because all alternatives face difficult challenges. We acknowledge other alternatives that could become more feasible in the future and that strategies to commercialize stranded gas resources could be different for each company.

To provide a realistic scenario, we have not analyzed gas development separate from oil development. Rather, we will analyze oil and gas activities as integrated operations because they are often similar and thus similar impacts. At the leasing stage, companies cannot distinguish between oil and gas pools. Drilling is the only way to test prospects for commercial-grade reservoirs and to determine which ones will contain producible oil or gas reserves. Furthermore, oil and gas often occur together in the subsurface. Oil reservoirs commonly contain associated-dissolved gas and extend upward into gas-bearing zones (gas caps). In most cases, both oil and gas would be produced through the same surface facilities. Likewise, gas pools often yield hydrocarbon liquids (condensate), so both gas and condensate would be recovered through the

same facilities. Shared development strategies improve the commercial logistics for nearby oil and gas fields.

For these reasons, it is more realistic to consider an integrated oil and gas development scenario, where either oil or gas (or more likely, a mixture) will be discovered and produced as a result of leasing in the Beaufort and Chukchi OCS. For the development scenario we assume that both oil and gas will be carried to market by pipeline systems from the central North Slope.

# APPENDIX F

# NOTICE TO LESSEES AND OPERATORS OF FEDERAL OIL AND GAS LEASES IN THE ALASKA OUTER CONTINENTAL SHELF REGION

**UNITED STATES DEPARTMENT OF THE INTERIOR**
**MINERALS MANAGEMENT SERVICE**
**ALASKA OCS REGION**

NTL No. 08-A01 Effective Date:

NOTICE TO LESSEES AND OPERATORS OF FEDERAL OIL AND GAS LEASES IN THE ALASKA OUTER CONTINENTAL SHELF REGION

# PROTECTION OF BIOLOGICAL RESOURCES

## Authority

This Notice to Lessees and Operators (NTL) is issued pursuant to regulations at 30 CFR 250.201 and 30 CFR 250.202.

## Purpose and Need for NTL

This NTL provides guidance to the lease owner/operator related to protection of previously unidentified biological populations or habitats that may be discovered during the conduct of any operations on a lease. It is issued to clarify and interpret the requirements contained in regulations for protection of such seafloor resources and does not impose additional requirements.

## Guidance

If, previously unidentified biological populations or habitats are discovered during the conduct of any operations on a lease, the lease owner/operator shall report such finding to the Regional Supervisor/Field Operations (RS/FO) within 72 hours of the discovery. The lease owner/operator shall make reasonable efforts to protect the biological resource from effects from operations until the RS/FO instructs the lease owner/operator on what measures, if any, are required to avoid or minimize adverse effects to the biological resource pursuant to 30 CFR 250.201 and 30 CFR 250.202.

**Paperwork Reduction Act of 1995 (PRA) Statement:** The collection of information referred to in this NTL is required in 30 CFR part 250, subparts B, D, J; and 30 CFR part 251. The Office of Management and Budget (OMB) approved the information collection requirements in these regulations and assigned OMB control numbers 1010-0049 for subpart B; 1010-0141 for subpart D; 1010-0044 is currently in the surnaming process to be consolidated into the primary collection for subpart D which includes Form MMS-123, Application for Permit to Drill that will be superseded by 1010-0141 when OMB approves; 1010-0050 for subpart J, and 1010-0048 for part 251. This NTL does not impose additional information collection requirements subject to the PRA.

**Alaska OCS Region Contacts**

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Jeffrey Walker
Regional Supervisor
Field Operations Office

**UNITED STATES DEPARTMENT OF THE INTERIOR**
**MINERALS MANAGEMENT SERVICE**
**ALASKA OCS REGION**

NTL No. 08-A02 Effective Date:

NOTICE TO LESSEES AND OPERATORS OF FEDERAL OIL AND GAS LEASES IN THE ALASKA OUTER CONTINENTAL SHELF REGION

**Protection Subsistence Whaling and Other Marine Mammal Subsistence-Harvest Activities**

## Authority

This Notice to Lessees and Operators (NTL) is issued pursuant to regulations at 30 CFR 250.202, 30 CFR 250.209, 30 CFR 250.212, 30 CFR 250.216, 30 CFR 250.223, 30 CFR 250.227, 30 CFR 250.242, 30 CFR 250.247, 30 CFR 250.254, and 30 CFR 250.261.

## Purpose and Need for NTL

This NTL provides guidance to the lease owner/operator related to protection of subsistence-harvest of whales and other marine mammals during the conduct of any operations on a lease. It is issued to clarify and interpret the requirements contained in regulations for protection of subsistence activities and does not impose additional requirements.

## Guidance

The MMS operating regulations at 30 CFR 250.202(d) and (e) state that proposed activities shall be conducted in a manner that does not unreasonably interfere with other uses of the OCS and does not cause undue of serious harm to the human environment. The regulations at 30 CFR 250.209 state that ancillary activities must comply with the performance standards listed in 30 CFR 250.202(d) and (e). Exploration, development, production, and support activities, including ancillary activities, shall be conducted in a manner that prevents reasonably foreseeable conflicts between the lease owner/operator activities and subsistence activities (including, but not limited to, bowhead whale and other marine mammal subsistence hunting).

Before submission of an Exploration Plan (EP) or Development and Production Plan (DPP), the lease owner/operator shall confer with the NSB, potentially affected subsistence communities, marine mammal co-management organizations, local whaling captains, MMS, the National Fisheries Management Service (NMFS), and the U.S. Fish and Wildlife Service (FWS) to identify critical marine mammal harvest areas and periods.

Before submission of an Exploration Plan (EP) or Development and Production Plan (DPP) for activities proposed during the bowhead whale migration period, during critical subsistence harvest periods, or within the community-designated subsistence-harvest areas, the lease owner/operator shall confer with the potentially affected subsistence communities and marine mammal co-management organizations to identify potential conflicts with the siting, timing, and methods of proposed operations and measures to be considered by the lessee for implementation to prevent unreasonable conflicts.

The EP or DPP submission shall include a list of agencies and persons consulted or to be consulted regarding potential impacts to subsistence activities. The EP or DPP shall also include a summary of the discussions, including identified critical marine mammal harvest areas and periods, potential conflicts, potential measures to prevent unreasonable conflicts, resolutions reached during the discussions, unresolved issues, and any plans for continued discussions.

Pursuant to 30 CFR 250.227 and 30 CFR 250.261, where proposed activities would take place near a traditional Arctic subsistence hunting area or may affect the availability of a species or stock of marine mammal for Arctic subsistence uses, the lease owner/operator shall include with any Exploration Plan (EP) or Development and Production Plan (DPP), submitted under 30 CFR 250.212 and 250.242 respectively, information that identifies what measures have been or will be taken to minimize potential adverse effects to subsistence activities and prevent unreasonable interference with subsistence activities. This information is necessary for MMS to complete required environmental analysis of activities proposed in an EP or DPP.

If proposed activities have the potential to adversely affect subsistence harvest activities, the EP or DPP shall include an Adaptive Management and Mitigation Plan (AMMP). The AMMP shall include the following:

a. A bowhead whale monitoring program, if applicable, that provides (on a frequency basis to be specified by the Regional Supervisor-Field Operations (RS-FO)) information on the presence, movements, and locations of bowhead whales during their migration and passage through subsistence whaling areas (a whale monitoring plan approved by NMFS in support of an IHA application would satisfy this requirement);
b. A plan for establishing communication center(s) to support and facilitate timely communications among responsible and affected parties;
c. A protocol for local whaling captains, appropriate co-management organizations, and local subsistence users to report through the communication center(s) the status subsistence activities, thus supporting information sharing, timely response, and appropriate mitigation of potential conflicts;
d. A protocol to notify the RS/FO of all concerns expressed by subsistence organizations during operations and of steps taken to address such concerns;
e. A protocol for the timely sharing and assessment of monitoring data with MMS, NMFS, and FWS, as appropriate, to enable the agencies to assess whether a sufficient number of whales remain available for community

subsistence hunts to meet subsistence needs. The RS-FO would make such a determination in consultation with NMFS, FWS, co-management organizations, directly affected subsistence communities, and the lessee/operator and with consideration of available information;

f. A plan for adaptive measures to be implemented to protect subsistence activities if determined necessary by the RS-FO. The adaptive measures should include progressively minimizing or shutting down noise-producing operations and/or a plan for moving vessels and/or drill structures out of whaling and migration corridors.

**g.** These information requirements may be met through obtaining Marine Mammal Protection Act authorizations through FWS and NMFS.

**Paperwork Reduction Act of 1995 (PRA) Statement:** The collection of information referred to in this NTL is required in 30 CFR part 250, subparts B, D, J; and 30 CFR part 251. The Office of Management and Budget (OMB) approved the information collection requirements in these regulations and assigned OMB control numbers 1010-0049 for subpart B; 1010-0141 for subpart D; 1010-0044 is currently in the surnaming process to be consolidated into the primary collection for subpart D which includes Form MMS-123, Application for Permit to Drill that will be superseded by 1010-0141 when OMB approves; 1010-0050 for subpart J, and 1010-0048 for part 251. This NTL does not impose additional information collection requirements subject to the PRA.

**Contacts**

**Alaska Official Contacts**

| **Titles** | **Contact** | **E-mail Address** | **Phone** |
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**UNITED STATES DEPARTMENT OF THE INTERIOR**
**MINERALS MANAGEMENT SERVICE**
**ALASKA OCS REGION**

NTL No. 08-A03 Effective Date:

NOTICE TO LESSEES AND OPERATORS OF FEDERAL OIL AND GAS LEASES IN THE ALASKA OUTER CONTINENTAL SHELF REGION

**Industry Site-Specific Marine Mammal Monitoring Programs**

## Authority

This Notice to Lessees and Operators (NTL) is issued pursuant to regulations at 30 CFR 250.201, 30 CFR 250.202, 30 CFR 250.221(b), 30 CFR 250.223, 30 CFR 250.252(b), 30 CFR 250.254, and 30 CFR 250.282.

## Purpose and Need for NTL

This NTL provides guidance to the lease owner/operator related to monitoring of marine mammals during the conduct of any operations on a lease. It is issued to clarify and interpret the requirements contained in regulations for conduct of activities in a manner consistent with the provisions of the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA) and does not impose additional requirements.

## Guidance

The MMS final rule published in the Federal Register on April 13, 2007 (Volume 72, Number 71, pages 18577-18585) requires OCS lease owners/operators to provide information on how they will conduct their proposed activities in a manner consistent with the provisions of the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA). The final rule identifies environmental, monitoring, and mitigation information that must be submitted with Exploration Plans (EPs) and Development and Production Plans (DPPs). The final rule requires lease owners/operators to describe how they will mitigate the potential for takes to occur, monitor for potential takes, and report takes should they occur.

The MMS operating regulations at 30 CFR 250.221(b) and 30 CFR 250.223 are requirements for EPs to include descriptions of monitoring and mitigation measures to address federally listed species and marine mammals if there is reason to believe the exploration activities may result in an incidental take. The MMS operating regulations at 30 CFR 250.252(b) and 30 CFR 250.254 are requirements for DPPs to include descriptions of monitoring and mitigation measures to address federally listed species and marine mammals if there is reason to believe the development and production activities may result in an incidental take.

**Paperwork Reduction Act of 1995 (PRA) Statement:** The collection of information referred to in this NTL is required in 30 CFR part 250, subparts B, D, J; and 30 CFR part 251. The Office of Management and Budget (OMB) approved the information collection requirements in these regulations and assigned OMB control numbers 1010-0049 for subpart B; 1010-0141 for subpart D; 1010-0044 is currently in the surnaming process to be consolidated into the primary collection for subpart D which includes Form MMS-123, Application for Permit to Drill that will be superseded by 1010-0141 when OMB approves; 1010-0050 for subpart J, and 1010-0048 for part 251. This NTL does not impose additional information collection requirements subject to the PRA.

**Contacts**

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**UNITED STATES DEPARTMENT OF THE INTERIOR**
**MINERALS MANAGEMENT SERVICE**
**ALASKA OCS REGION**

NTL No. 08-A04 Effective Date:

NOTICE TO LESSEES AND OPERATORS OF FEDERAL OIL AND GAS LEASES IN THE ALASKA OUTER CONTINENTAL SHELF REGION

**Marine Mammal Protection Act Authorizations**

## Authority

This Notice to Lessees and Operators (NTL) is issued pursuant to regulations at 30 CFR 250.201, 30 CFR 250.202, 30 CFR 250.221(b), 30 CFR 250.223, 30 CFR 250.252(b), 30 CFR 250.254, and 30 CFR 250.282.

## Purpose and Need for NTL

It is the responsibility of the MMS to require that lessees and operators conduct their activities in a manner that is consistent with the provisions of the Marine Mammal Protection Act (MMPA). This NTL provides guidance to the lease owner/operator related to the need for obtaining authorization from the National Marine Fisheries Service and/ or the U.S. Fish and Wildlife Service (FWS) pursuant to the MMPA. It is issued to clarify and interpret the requirements contained in regulations for conduct of activities in a manner consistent with the provisions of the MMPA and does not impose additional requirements.

## Guidance

The MMS final rule published in the Federal Register on April 13, 2007 (Volume 72, Number 71, pages 18577-18585) requires Outer Continental Shelf (OCS) lease owners/operators to provide information on how they will conduct their proposed activities in a manner consistent with the provisions of the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA). The MMS operating regulations at 30 CFR 250.221(b) and 30 CFR 250.223 are requirements for Exploration Plans to include descriptions of monitoring and mitigation measures to address federally listed species and marine mammals if there is reason to believe the exploration activities may result in an incidental take. The MMS operating regulations at30 CFR 250.252(b) and 30 CFR 250.254are requirements for Development and Production Plans to include descriptions of monitoring and mitigation measures to address federally listed species and marine mammals if there is reason to believe the development and production activities may result in an incidental take.

While industry is under no legal requirement to obtain incidental take authorization under the MMPA, the OCS Lands Act mandates "The Constitution and laws and civil and political jurisdiction of the United States (U.S.) are extended to the subsoil and seabed of the OCS and to all artificial islands, and all installations and other devices permanently or temporarily attached to the seabed which may be erected thereon for the purpose of exploring for, developing, or producing resources therefrom, or any such installation or other device (other than a ship or vessel) for the purpose of transporting such resources…" Those laws include the ESA and the MMPA. Every lease the MMS issues contains a requirement that the lessee must comply with applicable laws.

The MMPA allows the action proponent to make the determination of whether its activities are likely to result in a take of a marine mammal and whether the proponent will apply for authorization for incidental take under the MMPA.

Lease owners/operators are hereby notified that if the Regional Supervisor/Field Operations disagrees with a lease owner/operator's determination that a marine mammal take is unlikely to occur, MMS will not approve the proposed activities. The MMS will not authorize activities that it believes may result in an unauthorized, and therefore illegal, incidental take.

The FWS has issued regulations for incidental take authorization for conducting oil and gas activities in polar bear and walrus habitat. Where an oil and gas activity may affect the polar bear or walrus, the most expeditious and orderly process for the lease owner/operator to comply with the MMPA is by applying for a Letter of Authorization (LOA) from FWS Division of Marine Mammals Management (MMM). The FWS 4(d) rule (FR 73(95): 28306-28318) stated that if an activity is permissible under the stricter standards of the MMPA, it is also permissible under the ESA with respect to the polar bear. Issuance of a, LOA/Incidental Take Statement (ITS) from FWS to the lease owner/operator will provide incidental take coverage under the MMPA and the ESA. With issuance of LOA/ITS from FWS, MMS will meet its ESA obligations. If the lessee owner/operator does not apply for and receive an LOA/ITS from FWS, the MMS must reinitiate ESA section 7 consultation on the proposed activities.

**Paperwork Reduction Act of 1995 (PRA) Statement:** The collection of information referred to in this NTL is required in 30 CFR part 250, subparts B, D, J; and 30 CFR part 251. The Office of Management and Budget (OMB) approved the information collection requirements in these regulations and assigned OMB control numbers 1010-0049 for subpart B; 1010-0141 for subpart D; 1010-0044 is currently in the surnaming process to be consolidated into the primary collection for subpart D which includes Form MMS-123, Application for Permit to Drill that will be superseded by 1010-0141 when OMB approves; 1010-0050 for subpart J, and 1010-0048 for part 251. This NTL does not impose additional information collection requirements subject to the PRA.

**Contacts**

**Alaska Official Contacts**

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**Information to Lessees. At-Sea Fuel Transfers.**

Lessees are advised that all at-sea fuel-transfers conducted in support of activities related to exploration and development of leases issued as a result of this sale will be subject to the provisions of the following:

- Oil Pollution Act of 1990;
- Executive Order 12777: Implementation of Section 311 of the Federal Water Pollution Control Act of October 18, 1972, as Amended, and the Oil Pollution Act of 1990 (http://www.mms.gov/offshore/OilSpillProgram/Assets/PDFs/EO12777-OSP.pdf);
- Memorandum of Agreement Between the Minerals Management Service-U.S. Department of the Interior and the U.S. Coast Guard-U.S. Department of Homeland Security (MMS/USCG MOA: OCS-04 Floating Offshore Facilities) (http://www.mms.gov/MOU/PDFs/MOA-USCG04FloatingFacilities-Final.pdf); and
- U.S. Coast Guard implementing regulations at 33 CFR 156 Subpart C - Special Requirements for Lightering of Oil and Hazardous Material Cargoes (http://frwebgate.access.gpo.gov/cgi-bin/get-cfr.cgi).

**Information to Lessees. Transportation of Hydrocarbons.**

Lessees are advised the Minerals Management Service Alaska OCS Region considers pipelines to be the preferred method for transportation of OCS-produced oil to shore.

Pipelines will be required for proposed OCS development and production: (a) if pipeline rights-of-way can be determined and obtained; (b) if laying such pipelines is technologically feasible and environmentally preferable; and (c) if pipelines can be laid without net social loss, taking into account any incremental costs of pipelines over alternative methods of transportation and any incremental benefits in the form of increased environmental protection. In authorizing the means of transportation of OCS-produced hydrocarbons, MMS will give due consideration to recommendations of any advisory groups and Federal, State, and local governments and industry.

Following the development of sufficient pipeline capacity, no crude oil production will be transported by surface vessel from offshore production sites, except in the case of an emergency. Determination as to emergency conditions and appropriate responses to these conditions will be made by the Regional Supervisor/Field Operations.

**Information to Lessees. Information on the Spectacled Eider and Steller's Eider**.

Lessees are advised that the spectacled eider (*Somateria fischeri*) and Steller's eider (*Polysticta stelleri*) are listed as threatened by the Fish and Wildlife Service (FWS) and are protected by the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.).

Spectacled eiders and Steller's eiders are present in the Chukchi Sea during spring migration in May and June. Males return to the open sea in late June, while nesting females remain on the arctic coastal tundra until late August or early September, when they move to coastal areas of the Beaufort and Chukchi seas for brood-rearing. Molting eiders occur in certain offshore areas until freeze-up (typically in November). Onshore activities related to OCS exploration, development, and production during the summer months (May-September) may affect nesting spectacled eiders and Steller's eiders.

Lessees are advised that exploration and development and production plans submitted to MMS will be reviewed by the FWS to ensure that spectacled eider, Steller's eider, and their habitats are protected. For the proposed lease sales, MMS is specifically requesting an incremental Section 7 consultation with the FWS. The MMS will consult with FWS on the potential effects of leasing and seismic/exploration activities.

As few details are known regarding the specific location/design of a future development, therefore that stage of activity will require further consultation with the FWS. To allow this stepwise approach, FWS must find that the leasing and seismic/exploration stage of the lease sales would not result in a jeopardy determination to either the Steller's eider or spectacled eider nor would adverse modification of spectacled eider critical habitat occur.

The FWS also must evaluate MMS's evaluation of potential development and production that could occur as a result of leasing and exploration locating a commercially viable discovery, and conclude that there is a reasonable likelihood that the entire action will not violate Section 7(a)(2) of the Endangered Species Act. Section 7(a)(2) of the Act requires that Federal Agencies ensure their actions are not likely to jeopardize the continued existence of any endangered or threatened species or adversely modify designated critical habitat. Lessees are advised that future development projects arising from lease sales in the Chukchi (212 and 221) and Beaufort (209 and 217) seas will be subject to future Section 7 consultation with the FWS and a future project would not be authorized by MMS if it is likely to result in jeopardy or adverse modification of designated critical habitat as determined by FWS.

Stipulation 2 states that lessees are required to adhere to the conditions of the most recent Biological Opinion issued by the FWS pertaining to post-lease activities. At the time the draft EIS was prepared, the following conditions apply to (A) the Beaufort and (B) the Chukchi sea sales.

**(A) Beaufort Sea: Measures to Minimize Effects to Spectacled and Steller's Eiders during Exploration Activities in the Beaufort Sea.**

The following measures minimize the likelihood that Steller's and spectacled eiders would strike drilling structures or vessels. They also provide additional protection to eiders within other important areas, including the Ledyard Bay Critical Habitat Area, during times when eiders are present. The mitigation measures would protect ESA-listed and other marine and coastal birds during seismic activities and exploration drilling operations in the Beaufort Sea. These measures are consistent with recent Section 7 consultations for Lease Sales 186, 195, and 202 and programmatic seismic activities in the Beaufort Sea. Case-by-case exceptions require reconsultation under the ESA with the FWS.

**A) General Conditions:** The following conditions apply to all lease exploration and support activities.

(1) Vessels will minimize the use of high-intensity work lights, especially within the 20-m-bathymetric contour. Exterior lights will be used only as necessary to illuminate active, on-deck work areas during periods of darkness or inclement weather (such as rain or fog), otherwise they will be turned off. Interior lights and lights used during navigation could remain on for safety.

(2) An Exploration Plan, ancillary activities, and other proposed lease activities must include a plan for recording and reporting bird strikes. All bird collisions (with vessels, aircraft, or drilling structures) shall be documented and reported within 3 days to MMS. Minimum information will include species, date/time, location, weather, identification of the vessel, aircraft or drilling structure involved and its operational status when the strike occurred. Bird photographs are not required, but would be helpful in verifying species. Lessees are advised that the U.S. Fish and Wildlife Service (FWS) does not recommend recovery or transport of dead or injured birds due to avian influenza concerns.

**B) Seismic Activities**: The following conditions apply to any seismic survey activities and supporting vessels and aircraft supporting those activities.

(1) No vessels associated with Beaufort Sea seismic survey activity en route to the Beaufort Sea will be permitted within the Ledyard Bay Critical Habitat Area following July 1 of each year, unless human health or safety dictates otherwise.

(2) Seismic-survey support aircraft would maintain at least a 1,500 ft (305 m) altitude over beaches, lagoons, and nearshore waters of the Beaufort Sea as much as possible. Support aircraft associated with Beaufort Sea seismic survey activities are not expected to operate over the Ledyard Bay Critical Habitat Area. If so, however, aircraft must avoid overflights across the Ledyard Bay Critical Habitat Area below an altitude of 1,500 feet (450 meters) after July 1 of each year, unless human health or safety dictates otherwise.

(3) Whenever vessels are in the marine environment, there is a possibility of a fuel or toxic substance spill. If seismic-related vessels transit through the spring lead

system before June 10 they may encounter concentrations of listed eiders. These vessels are required to have wildlife hazing equipment (including Breco buoys or similar equipment) pre-staged, and readily accessible by personnel trained in their use, either on the vessel, at Point Lay or Wainwright, or on an on-site Oil Spill Response Vessel, in order to ensure rapid deployment in the event of a spill.

(4) The spring lead system is defined as the Ledyard Bay Critical Habitat Area as well as the Federal OCS areas landward from an imaginary line extending from the outer corner of the Critical Habitat Area (70°20'00" N. x 164°00'00" W.) extending northeast to the southeastern-most corner of the Lease Sale 193 Sale Area (71°39'35" N. x 156°00'00" W.) and the area landward of an imaginary line drawn between Point Hope and the other outer corner of the Ledyard Bay Critical Habitat Area (69°12'00" N. x 166°13'00" W.).

**C) Drilling Activities:** The following conditions apply to operations conducted in support of exploratory and delineation drilling.

(1) Surface vessels (e.g., boats, barges) associated with exploration and delineation drilling operations should avoid operating within or traversing the Chukchi Sea spring lead system between April 15 and June 10 to the maximum extent practicable. If surface vessels must traverse this area during this period, the surface vessel operator will have ready access to wildlife hazing equipment (including at least 3 *Breco* buoys or similar devices) and personnel trained in its use; hazing equipment may be located on-board the vessel or on a nearby Oil Spill Response Vessel, or in Point Lay or Wainwright. Lessees are required to provide information regarding their operations within the area upon request of MMS. The MMS may request information regarding number of vessels and their dates of operation within the area.

(2) Except for emergencies or human/navigation safety, surface vessels associated with Beaufort Sea exploration and delineation drilling operations will avoid travel within the Ledyard Bay Critical Habitat Area between July 1 and November 15. Vessel travel within the Ledyard Bay Critical Habitat Area for emergencies or human/navigation safety shall be reported within 24 hours to MMS.

**D) Lighting Protocols.** The following requirements apply to all new and existing Outer Continental Shelf oil and gas leases issued west of 146° W. longitude for activities conducted between April 15 and November 15. The MMS encourages operators to consider such measures in areas to the east of 146° W. longitude because occasional sightings of listed eiders have been made there and because such measures could reduce the potential for collisions of other, non-ESA listed migratory birds that are protected under the Migratory Bird Treaty Act.

Lessees are required to implement lighting requirements aimed at minimizing the radiation of light outward from exploration or delineation drilling structures to minimize the likelihood that birds would strike those structures. These requirements establish a coordinated process for a performance-based objective rather than pre-determined prescriptive requirements. The performance-based objective is to minimize the radiation of light outward from exploration/delineation structures while operating on a lease or if staged within nearshore federal waters pending lease deployment.

Measures to be considered include but need not be limited to the following:
(1) Shading and/or light fixture placement to direct light inward and downward to living and work structures while minimizing light radiating upward and outward;
(2) Types of lights;
(3) Adjustment of the number and intensity of lights as needed during specific activities;
(4) Dark paint colors for selected surfaces;
(5) Low-reflecting finishes or coverings for selected surfaces; and
(6) Facility or equipment configuration.

Lessees are encouraged to consider other technical, operational and management approaches that could be applied to their specific facility and operation to reduce outward light radiation. Lessees must provide MMS with a written statement of measures that will be or have been taken to meet the lighting objective and submit this information with an Exploration Plan when it is submitted for regulatory review and approval pursuant to 30 CFR 250.203.

Nothing in this ITL is intended to reduce personnel safety or prevent compliance with other regulatory requirements (e.g., U.S. Coast Guard or Occupational Safety and Health Administration) for marking or lighting of equipment and work areas.

**(B) Chukchi Sea: Measures to Minimize Effects to Spectacled and Steller's Eiders during Exploration Activities in the Chukchi Sea.**

The following measures minimize the likelihood that Steller's and spectacled eiders would strike drilling structures or vessels. They also provide additional protection to eiders within other important areas, including the Ledyard Bay Critical Habitat Area, during times when eiders are present. The mitigation measures would protect birds listed under the Endangered Species Act ("ESA-listed") and other marine and coastal birds during seismic activities and exploration drilling operations in the Chukchi Sea. These measures are consistent with the recent Section 7 consultations for Lease Sale 193 and programmatic seismic activities in the Chukchi Sea. Case-by-case exceptions require re-consultation under the ESA with the FWS.

**A) General Condition.** The following conditions apply to all lease exploration and support activities.

(1) Vessels will minimize the use of high-intensity work lights, especially when traversing the spring lead system. Exterior lights will be used only as necessary to illuminate active, on-deck work areas during periods of darkness or inclement weather (such as rain or fog), otherwise they will be turned off. Interior lights and lights used during navigation could remain on for safety.

(2) An Exploration Plan, ancillary activities, and other proposed lease activities must include a plan for recording and reporting bird strikes. All bird collisions (with vessels, aircraft, or drilling structures) shall be documented and reported within 3 days to MMS. Minimum information will include species, date/time, location, weather, identification of the vessel, aircraft or drilling structure involved and its operational status when the strike occurred. Bird photographs are not required, but would be helpful in verifying species. Lessees are advised that the U.S. Fish and Wildlife Service (FWS) does not recommend recovery or transport of dead or injured birds due to avian influenza concerns.

**B) Seismic Activities.** The following conditions apply to any seismic survey and the supporting vessels and aircraft supporting those activities.

(1) No vessels associated with seismic survey activity, including re-supply and other related vessels, will be permitted within the Ledyard Bay Critical Habitat Area following July 1 of each year, unless human health or safety dictates otherwise.

(2) Seismic survey support aircraft must avoid overflights across the Ledyard Bay Critical Habitat Area below an altitude of 1,500 ft (450 m) above sea level (ASL) after July 1 of each year, unless human health or safety dictates otherwise. Seismic-survey support aircraft shall maintain at least a 1,500 ft (450 m) altitude over beaches, lagoons, and nearshore waters as much as possible. Designated aircraft flight routes will be established for situations when aircraft associated with seismic activity cannot maintain at least 1,500 ft ASL over the Ledyard Bay Critical Habitat Area.

(3) Whenever vessels are in the marine environment, there is a possibility of a fuel or toxic substance spill. If vessels transit through the spring lead system before June 10 they may encounter concentrations of ESA-listed eiders. These vessels are required to have wildlife hazing equipment (including Breco buoys or similar equipment) pre-staged, and readily accessible by personnel trained in their use, either on the vessel, at Point Lay or Wainwright, or on an on-site Oil Spill Response Vessel, in order to ensure rapid deployment in the event of a spill.

(4) The spring lead system is defined as the Ledyard Bay Critical Habitat Area as well as the Federal OCS areas landward from an imaginary line extending from the outer corner of the Critical Habitat Area (70°20’00” N. x 164°00’00” W.) extending northeast to the southeastern-most corner of the Lease Sale 193 Area (71°39’35” N. x 156°00’00” W.) and the area landward of an imaginary line drawn between Point Hope and the other outer corner of the Ledyard Bay Critical Habitat Area (69°12’00” N. x 166°13’00” W.).

**C) Drilling Activities:** The following conditions apply to operations conducted in support of exploratory and delineation drilling.

(1) Surface vessels (e.g., boats, barges) associated with exploration and delineation drilling operations should avoid operating within the Spring Lead System between April 15 and June 10 to the maximum extent practicable. If surface vessels must traverse this area during this period, the surface vessel operator will have ready access to wildlife hazing equipment (including at least 3 *Breco* buoys or similar devices) and personnel trained in its use; hazing equipment may be located on-board the vessel or on a nearby Oil Spill Response Vessel, or in Point Lay or Wainwright. Lessees are required to provide information regarding their operations within the area upon request of MMS. The MMS may request information regarding number of vessels and their dates of operation within the area.

(2) Except for emergencies or human/navigation safety, surface vessels associated with exploration and delineation drilling operations will avoid travel within the Ledyard Bay Critical Habitat Area between July 1 and November 15. Vessel travel within the Ledyard Bay Critical Habitat Area for emergencies or human/navigation safety shall be reported within 24 hours to MMS.

(3) Aircraft supporting drilling operations will avoid operating below 1,500 ft ASL over the spring lead system between April 15 and June 10 and the Ledyard Bay Critical Habitat Area between July 1 and November 15 to the maximum extent practicable. If weather prevents attaining this altitude, aircraft will use pre-designated flight routes. Pre-designated flight routes will be established by the lessee and MMS, in collaboration with the FWS, during review of the Exploration Plan. Route or altitude deviations for emergencies or human safety shall be reported within 24 hours to MMS.

**D) Lighting Protocols.** The following requirements apply to all activities conducted between April 15 and November 15 in the Chukchi Sea.

Drilling Structures: Lessees are required to implement lighting requirements aimed at minimizing the radiation of light outward from exploration or delineation drilling structures to minimize the likelihood that birds would strike those structures. These requirements establish a coordinated process for a performance-based objective rather than pre-determined prescriptive requirements. The performance-based objective is to minimize the radiation of light outward from exploration/delineation structures while operating on a lease or if staged within nearshore federal waters pending lease deployment.

Measures to be considered include but need not be limited to the following:

(1) Shading and/or light fixture placement to direct light inward and downward to living and work structures while minimizing light radiating

upward and outward;
(2) Types of lights;
(3) Adjustment of the number and intensity of lights as needed during specific activities;
(4) Dark paint colors for selected surfaces;
(5) Low-reflecting finishes or coverings for selected surfaces; and
(6) Facility or equipment configuration.

Lessees are encouraged to consider other technical, operational and management approaches that could be applied to their specific facility and operation to reduce outward light radiation. Lessees must provide MMS with a written statement of measures that will be or have been taken to meet the lighting objective and submit this information with an Exploration Plan when it is submitted for regulatory review and approval pursuant to 30 CFR 250.223.

Nothing in this ITL is intended to reduce personnel safety or prevent compliance with other regulatory requirements (e.g., U.S. Coast Guard or Occupational Safety and Health Administration) for marking or lighting of equipment and work areas.

The following condition "E" is only required if lease sales 212 or 221 include part of LBCHA (Alternatives 2, 5, and 6).

**E) Exploratory Drilling Operations in the Ledyard Bay Critical Habitat Area.** The following condition applies to any exploratory and delineation drilling operations proposed to occur in the Ledyard Bay Critical Habitat Area (July 1–November 15).

The drill rig and support vessels must enter the Ledyard Bay Critical Habitat Area from the northwest and proceed directly to the drill site. Support vessels will remain in close proximity to the drill rig while providing support and exit the drill rig vicinity to the northwest until out of the Critical Habitat Area. Deviations from this routing shall be reported within 24 hours to MMS.

# APPENDIX G

## Reserved For Future Use

# APPENDIX H

# ESA CONSULTATION

**UNITED STATES DEPARTMENT OF COMMERCE**
**National Oceanic and Atmospheric Administration**
*National Marine Fisheries Service*
*P.O. Box 21668*
*Juneau, Alaska 99802-1668*

July 17, 2008

John Goll
Director, Alaska Outer Continental Shelf Region
Minerals Management Service
3801 Centerpoint Drive, Suite 500
Anchorage, Alaska 99503-5823

Dear Mr. Goll:

This document transmits National Marine Fisheries Service's (NMFS) revised Biological Opinion for Federal oil and gas leasing and exploration by the Minerals Management Service (MMS) within the Alaskan Beaufort and Chukchi Seas, and its effects on the endangered fin, humpback and bowhead whale in accordance with section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.). Your May 8, 2008 letter to NMFS requested re-initiation of consultation in this matter. The MMS has provided a Biological Evaluation of leasing and exploration actions in the Beaufort and Chukchi Seas, which was received on May 14, 2008. We acknowledged receipt of this information and initiated formal consultation in our letter dated June 3, 2008.

This Biological Opinion is based on information provided in the May 2008 Biological Evaluation and other sources of information. A complete administrative record of this consultation is on file at the NMFS offices in Anchorage.

NMFS concludes the described actions are not likely to jeopardize the continued existence of the fin, humpback, or bowhead whale. In formulating this opinion, NMFS used the best available information, including information provided by MMS, recent research on the effects of oil and gas activities on the bowhead whale, and the traditional knowledge of Native hunters and the Inupiat along Alaska's north slope. Although we conclude that foreseeable exploration activities are not likely to jeopardize the continued existence of these whales, we remain concerned about the potential additive effects of oil and gas activities associated with exploration, production, and transportation throughout the Beaufort and Chukchi Seas. Conservation recommendations are provided with the opinion which are intended to improve our understanding of the impacts of oil and gas activities on these whales, as well as to minimize or mitigate adverse effects.

Sincerely,

Robert D. Mecum

Robert D. Mecum
Acting Administrator, Alaska Region

For:

Biological Opinion for Oil and Gas Leasing and Exploration Activities in the Beaufort and Chukchi Seas, Alaska; and Authorization of Small Takes Under the Marine Mammal Protection Act, July 2008.

See:

http://www.mms.gov/alaska/ref/Biological_opinions_evaluations.htm

United States Department of the Interior
U.S. FISH AND WILDLIFE SERVICE
Fairbanks Fish and Wildlife Field Office
101 12th Avenue, Room 110
Fairbanks, Alaska 99701



Memorandum

JUL 15 2008

To: Regional Director
Minerals Management Services, Alaska OCS Region

From: Field Supervisor
Fairbanks Fish and Wildlife Field Office

Subject: Request for Re-initiation of Section 7 Consultation for Polar Bear – Beaufort and Chukchi Seas

The U. S. Fish and Wildlife Service (Service) received your letters dated June 27, 2008 in which Minerals Management Service (MMS): 1) requested re-initiation of consultation activities for the Beaufort and Chukchi Seas for polar bears (*Ursus maritimus*,) pursuant to section 7 of the Endangered Species Act of 1973, as amended (ESA); 2) sought confirmation of your understanding of the polar bear-ESA consultation process under the Marine Mammal Protection Act (MMPA) Incidental Take Regulations (Regulations); and 3) provided a list of lease sales that might require ESA consultation due to possible effects to polar bears.

The Service recognizes that consultation requirements have changed since the polar bear was listed as a threatened species on May 15, 2008 (73 FR 28211). Because the polar bear now receives protection under both the MMPA and ESA, the Service has sought an approach to coordinate the ESA consultation requirements for polar bears in Alaska with the requirements of the MMPA. Section 101(a)(5) of MMPA allows for the incidental take of small numbers of marine mammals, in response to requests by U.S. citizens engaged in a specified activity (other than commercial fishing) in a specified geographic region; section 7(o)(2) of ESA allows for exemptions, under certain circumstances, to the take prohibitions for endangered and threatened species incidental to otherwise lawful activities that have Federal involvement or control. If a marine mammal species is listed as endangered or threatened under the ESA, the requirements of both MMPA and ESA must be met before the incidental take can be authorized.

Regarding MMS-permitted activities that may result in incidental take of polar bears, the Service recently concluded intra-Service programmatic section 7 consultations for the polar bear on the Chukchi Sea MMPA Regulations, and the Beaufort Sea MMPA Regulations for permitted activities of the oil and gas industry (see References below). Those biological opinions (BOs) determined it was unlikely the Regulations will violate section 7(a)(2) of the ESA. The intra-Service BOs also provided an ESA/MMPA

coordination mechanism for oil and gas project applicants. For applicant requests that fall within the parameters of the Regulations and BOs, the Service's Marine Mammal Management Office (MMM) will issue a combined Letter of Authorization (LOA)/Incidental Take Statement (ITS) that will provide incidental take coverage under both Acts.

Therefore, your understanding from our meetings on May 23 and June 19, 2008, is correct; MMS will meet its ESA consultation with the issuance of a combined LOA/ITS from the Service's MMM. The Service's intra-Service consultation on the Regulations extends section 7 coverage for proposed activities to other Federal agencies that also provide permits for the activities, provided the permittee acquires an LOA and complies with all mitigation measures. Issuance of the LOA/ITS will fulfill ESA consultation requirements for all federal agencies for that action.

The Service also appreciates the approach proposed in your letters indicating MMS will encourage all applicants to obtain LOAs or determine, with input from MMM, whether one is needed, and to make relevant spill plans available for Service review.

We look forward to discussing the various lease sales in the Beaufort and Chukchi Seas that may need consultation. If you or your staff can provide additional information about the activities of each, we will work with you to determine which will require a consultation for polar bears, discuss data needs and/or the need for a biological assessment in order to initiate consultation, and prioritize the workload.

Thank you for your cooperation in our joint responsibilities in providing conservation for the polar bear. If you have further question, please contact Ted Swem, Endangered Species Branch Chief, Fairbanks Fish and Wildlife Field Office at 907/456-0441.

**References:**

U.S. Fish and Wildlife Service. Programmatic Biological Opinion for Polar Bears (*Ursus maritimus*) on Chukchi Sea Incidental Take Regulations. May 28, 2008. Fairbanks Fish and Wildlife Field Office, Fairbanks, Alaska. 74 pp.

U.S. Fish and Wildlife Service. Programmatic Biological Opinion for Polar Bears (*Ursus maritimus*) on Beaufort Sea Incidental Take Regulations. June 23, 2008. Fairbanks Fish and Wildlife Field Office, Fairbanks, Alaska. 65 pp.

# United States Department of the Interior

MINERALS MANAGEMENT SERVICE
Alaska Outer Continental Shelf Region
3801 Centerpoint Drive, Suite 500
Anchorage, Alaska 99503-5823

Memorandum

JUN 27 2008

To: Regional Director
U. S. Fish and Wildlife Service, Region 7

From: Regional Director

Subject: Request for Re-initiation of Section 7 Consultation for Polar Bear – Beaufort Sea

As a result of the polar bear being listed as a threatened species under the Endangered Species Act (ESA) on May 15, 2008, the Minerals Management Service (MMS) is reviewing previously-authorized activities in the Beaufort Sea. The U.S. Fish and Wildlife Service (FWS) 4(d) rule (FR 73(95): 28306-28318) stated that if an activity is permissible under the stricter standards of the Marine Mammal Protection Act (MMPA), it is also permissible under the ESA with respect to the polar bear. We further understand, per our meetings on May 23 and June 19, 2008, that MMS will meet its ESA obligations with the issuance of a Letter of Authorization/Incidental Take Statement (ITS) from the FWS Division of Marine Mammals Management (MMM), which will provide incidental take coverage under the MMPA and the ESA.

While industry is under no legal requirement to obtain incidental take authorization, since 1991, industry has requested, and the FWS has issued regulations for, incidental take authorization for conducting oil and gas activities in polar bear habitat. Where an oil and gas activity may affect the polar bear, the most expeditious and orderly process for the lessee/operator to comply with the MMPA is by applying for a Letter of Authorization (LOA) from MMM. The lessee/operator would then conduct their activities in a manner consistent with conditions specified in the LOA. The Incidental Take Regulations (ITRs) in 50 CFR Part 18 (FR 71(148): 43926-43953) described the oil and gas activities MMS considered reasonably foreseeable in the Beaufort Sea. These same oil and gas activities were evaluated in the FWS intra-service biological opinion (BO, dated June 23, 2008). This BO resulted in a "no jeopardy" conclusion and developed a process to incorporate section 7 consultations under the ESA into the established framework for processing LOAs.

Due to the change in listing status of the polar bear, MMS will encourage all applicants to obtain LOAs or determine, with input from the MMM, that one is not needed. The applicant or the MMS will make relevant spill response plans available for review by the FWS. For requests that fall within the parameters of the ITRs, MMM will issue an LOA/ITS, which will provide incidental take coverage under both the MMPA and the ESA. As we authorize exploration and development/production actions covered by the ITRs, we understand that the issuance of an

LOA/ITS fulfills our consultation requirements, as well as those of the other agencies permitting the action, as these activities are fully evaluated under the ITRs and associated BO.

To ensure that all reasonably foreseeable MMS-permitted oil and gas activities are in compliance with the ESA, we are formally requesting to reinitiate Section 7 consultation because activities conducted under geologic and geophysical permits, ancillary authorizations, exploration plans, and development plans may affect the polar bear in the Beaufort Sea.

We request your acknowledgement that 1) we have reinitiated consultation regarding MMS-authorized activities on the polar bear and that 2) our understanding of the ESA consultation process under the ITRs is correct.

There are existing leases from Beaufort Sea Lease Sales 124, 144, 170, 186, 195, and 202. We have previously fulfilled our obligations under an incremental step approach to compliance with the National Environmental Policy Act and the ESA for these lease sales; however, the required assessments did not evaluate the polar bear in the context of being a threatened species. Every lease the MMS issues contains a requirement that the lessee must comply with applicable laws. As MMS retains discretion and control over oil and gas activities that may affect polar bears through operating rules within 30 CFR Part 250 Subpart B, we have determined that the existence or issuance of leases resulting from a sale does not constitute an irretrievable or irreversible commitment of resources and will have no effect on the polar bear. However, we need to consult on the full range of future activities that could occur on the leases consistent with the provisions of our operating rules. As a consequence, we are also formally requesting to reinitiate programmatic Section 7 consultation with you on the potential effects that the activities arising from previous Beaufort Sea sales may have on the polar bear and request that you advise us how to proceed.

Please contact Dr. Cleve Cowles, Regional Supervisor, Leasing and Environment, at (907) 334-5230 or Ms. Deborah Cranswick, Chief, Environmental Assessment Section, at (907) 334-5267 should you have any questions or require additional information.

cc: Field Supervisor, Fairbanks Fish and Wildlife Field Office

# United States Department of the Interior

MINERALS MANAGEMENT SERVICE
Alaska Outer Continental Shelf Region
3801 Centerpoint Drive, Suite 500
Anchorage, Alaska 99503-5823

Mr. Doug Mecum
Acting Regional Administrator
Alaska Region
National Marine Fisheries Service
P.O. Box 21668
Juneau, Alaska 99802

MAY - 8 2008

Dear Mr. Mecum:

On December 3, 2007, Minerals Management Service (MMS) sent a letter to the National Marine Fisheries Service (NMFS) regarding the possible need to re-initiate consultation under the Endangered Species Act (ESA) on activities associated with oil and gas leasing and exploration in portions of the Beaufort Sea and Chukchi Sea Outer Continental Shelf (OCS) Planning Areas. In your most recent correspondence to us (letter dated January 10, 2008), you recommended that we re-initiate formal consultation to address new information on two endangered species of whales (humpback and fin). Your recommendation was premised, in part, on recent information that indicates these listed species may be affected by MMS leasing activity. In the NMFS 2006 Arctic Regional Biological Opinion (ARBO), NMFS stated that "because fin and humpback whales are not likely to occur within the action area (planning areas of the Chukchi and Beaufort Seas) they are not likely to be adversely affected by these actions and will not be addressed in this opinion" (ARBO, page 8).

We agree to the recommended re-initiation of formal consultation and we have prepared a supplement (enclosure) to our March 2006 Arctic Region Biological Evaluation (ARBE). The supplemental Biological Evaluation (BE) addresses new information regarding bowhead, fin, and humpback whales and focuses on the potential effects of airgun-supported seismic surveys conducted throughout all phases of oil and gas exploration, development, production and abandonment. Our intent is to complete a programmatic consultation for airgun-supported seismic surveys for all phases of OCS oil and gas activities so that seismic surveys proposed during later stages do not necessitate reinitiating consultation unless changing technologies, methods, or new information not considered in this BE requires us to do so. As you also recommended, our supplemental BE addresses the potential consequences of continued climate change and diminished sea ice on these species and their distribution.

The MMS concludes in the enclosed supplemental BE that new information regarding bowhead whales is not substantially different from that considered in 2006 ARBE and ARBO and would not alter the findings in those documents regarding that species. New information regarding fin whales indicates that fin whales are not expected to occur in the Chukchi Sea or Beaufort Sea OCS Planning Areas. The new information confirms that fin whales can occur in the Chukchi

Sea but that they are rare in the U.S. portion of the Chukchi Sea and they are more likely to occur near the Bering Strait. New information regarding humpback whales indicates humpback whales may occur within both the Chukchi Sea and Beaufort Sea OCS Planning Areas. If recent observations are indicative of a trend of increasing abundance and distribution of humpback whales in the U.S. Arctic Ocean, the humpback whales would likely be adversely affected by airgun-supported seismic survey activities associated with oil and gas activities throughout all phases of oil and gas exploration, development, production, and abandonment.

It is important to note that MMS has received permit applications from the oil and gas industry to conduct airgun-support seismic surveys in 2008 and NMFS has received requests for authorization for incidental take of marine mammals for proposed seismic survey exploration in the Chukchi and Beaufort seas. Seismic survey activities could begin as early as July 1, 2008, or as authorized by NMFS. To cover these proposed 2008 seismic survey activities and to facilitate a timely completion of the consultation process and the NMFS preparation of a supplemental ARBO, we have provided a complete comprehensive description of the proposed actions and possible effects. We are also available to assist you with preparing a supplemental ARBO. To meet the time-frames for MMS and NMFS actions on activities that we jointly regulate, we request that our agencies work together to complete this consultation by June 24, 2008.

Unless you provide written notice of deficiencies in the supplemental BE within 30-days of receiving this request, we will assume consultation is initiated upon receipt of this request. If you consider recommending measures to minimize impacts to threatened and endangered species or if you determine a jeopardy situation may exist for all or any part of the proposed action, we ask that you notify us as early as possible, according to 50 CFR §402.14(g)(5), to allow the MMS and the NMFS time to jointly discuss the findings. We believe that such discussions will facilitate the consultation and ensure effective protection of listed species. These discussions will also ensure that any proposed measures are within our authority to control and implement, and are feasible, appropriate, and effective.

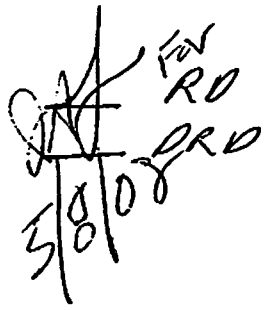
If you have any questions on this consultation or require additional information, please contact Dr. Cleve Cowles, Regional Supervisor, Office of Leasing and Environment at 907-334-5230 or Ms. Deborah Cranswick, Chief, Environmental Assessment Section, at 907 334-5267.

Sincerely,

for John Goll
Regional Director

Enclosure

cc w/enclosure: Mr. Brad Smith
Anchorage Field Office
National Marine Fisheries Service



Leasing &
Environment Office

- ☒ RSLE
- ☒ Chief EAS
- ☐ Chief ESS
- ☐ Chief, LAS
- ☐ _____
- ☐ Author
- ☐ _____

bcc: Official File (BEA) (ENV 3-2c)
Author File
AD/OMM
RD Chron File ✓
RSLE Chron File
RSRE Chron File
Chief, ENVD
Chief, BEA
J. Lewandowski, BEA

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For:

Supplement to the 2006 Biological Evaluation of the Potential Effects of Oil and Gas Leasing and Exploration in the Alaska OCS Beaufort Sea and Chukchi Sea Planning Areas on Endangered Bowhead Whales (*Balaena mysticetus*), Fin Whales (*Balaenoptera physalus*), and Humpback Whales (*Megaptera novaeangliae*).

See:

http://www.mms.gov/alaska/ref/Biological_opinions_evaluations.htm

**UNITED STATES DEPARTMENT OF COMMERCE**
**National Oceanic and Atmospheric Administration**
*National Marine Fisheries Service*
*P.O. Box 21668*
*Juneau, Alaska 99802-1668*

January 10, 2008

John Goll
Regional Director
Minerals Management Service
Alaska Outer Continental Shelf Region
3801 Centerpoint Drive, Suite 500
Anchorage, AK. 99503-5823

Dear Mr. Goll:

Minerals Management Service has contacted National Marine Fisheries Service regarding re-initiation of consultation under the Endangered Species Act (ESA) on activities associated with oil and gas leasing and exploration in portions of the Beaufort and Chukchi Seas planning areas (your December 3, 2007). We responded by letter dated December 13, 2007. After further discussion with your staff and our offices of Protected Resources and General Counsel, it is our recommendation to re-initiate formal consultation on this action in order to address new information and to account for two endangered species of whales which were not addressed under the existing consultation.

This re-initiation is premised, in part, on recent information that indicates additional listed species may be affected by this MMS leasing activity beyond the bowhead whale (the single species considered in the 2006 Arctic Regional Biological Opinion). Humpback and fin whales may now be present seasonally in the Chukchi and western Beaufort Seas. Preliminary information provided to us by MMS indicates the numbers of humpback whales observed from the seismic vessel M/V *Gilivar* in 2007 were quite high in relation to bowhead sightings, and that the distance of the humpbacks from the source vessel indicates a potential for these whales to be harassed by seismic survey noise.

We recommend MMS agree to the recommended re-initiation of consultation and prepare an updated Biological Evaluation (BE) on this action to address bowhead, humpback, and fin whales. Additionally, we recommend the BE consider the potential consequences of continued climate change and diminished sea ice on these species and their distribution. Our staff is available to discuss these issues throughout this consultation. If you have any questions or concerns about this consultation or the consultation process in general, please feel free to contact me or Mr. Brad Smith in our Anchorage office at (907) 271-3023.

Sincerely,

for Kaja Brix
Assistant Regional Administrator
For Protected Resources

**UNITED STATES DEPARTMENT OF COMMERCE**
**National Oceanic and Atmospheric Administration**
*National Marine Fisheries Service*
*P.O. Box 21668*
*Juneau, Alaska 99802-1668*

December 13, 2007

John Goll
Regional Director
Minerals Management Service
Alaska Outer Continental Shelf Region
3801 Centerpoint Drive, Suite 500
Anchorage, AK. 99503-5823

Dear Mr. Goll:

This letter acknowledges the National Marine Fisheries Service's receipt of your December 3, 2007 letter concerning re-initiation of consultation under the Endangered Species Act (ESA) on activities associated with oil and gas leasing and exploration in portions of the Beaufort and Chukchi Seas planning areas.

This re-initiation is premised, in part, on recent information that indicates additional listed species may be affected by this MMS leasing activity beyond the bowhead whale (the single species considered in the 2006 Arctic Regional Biological Opinion). Humpback and fin whales may be present seasonally in the Chukchi and western Beaufort Seas. At this time, the presence, movements, and distribution of humpback and fin whales in these waters are largely unknown. It will be necessary to evaluate whether these species have extended their range and may be regularly encountered in the future, or if these sightings are anomalous – possibly associated with unusual conditions in these waters. If these whales are determined to have a regular presence, their interaction with oil and gas activities should be assessed prior to further consultation under the ESA.

We are available to consult informally on this action and to work with your staff in making these determinations relative to section 7(a)(2) of the ESA. If you have any questions or concerns about this consultation or the consultation process in general, please feel free to contact me or Mr. Brad Smith in our Anchorage office at (907) 271-3023.

Sincerely,

Kaja Brix

Kaja Brix
Assistant Regional Administrator
For Protected Resources

# United States Department of the Interior

MINERALS MANAGEMENT SERVICE
Alaska Outer Continental Shelf Region
3801 Centerpoint Drive, Suite 500
Anchorage, Alaska 99503-5823

DEC 0 3 2007

James W. Balsiger, Ph.D.
Regional Administrator, Alaska Region
National Marine Fisheries Service
P. O. Box 21668
Juneau, Alaska 99802-1668

Dear Jim Balsiger:

The Minerals Management Service (MMS) proposes to reinitiate the Endangered Species Act (ESA) consultation to solicit National Marine Fisheries Service (NMFS) determination on required supplementation, if any, to the 2006 Arctic Regional Biological Opinion (ARBO) dated June 16, 2006. MMS requests NMFS concurrence with this proposal to reinitiate ESA consultation regarding new information on humpback and fin whales in the Chukchi and Beaufort Sea where current and anticipated Outer Continental Shelf (OCS) oil and gas exploration programs are active.

Marine Mammal Observer (MMO) reports received by MMS for 2006 and 2007 OCS-related operations and other sources, summarized and evaluated in Attachment 1, present recent occurrences of fin and humpback whales in the Arctic Beaufort and Chukchi Seas. These humpback and fin whale observations in the OCS Chukchi Sea and Beaufort Sea Planning Areas represent new information not considered in the ESA Section 7 consultation that resulted in the ARBO. That opinion stated:

> "Consultation will be re-initiated if...new information indicates these actions are impacting... other listed species... to a degree or in a manner not previously considered..."

As humpback and fin whales were not anticipated to occur in the either Chukchi Sea or Beaufort Sea Planning Areas (consolidated into the Arctic Region), MMS concluded there would be *no effect* on these species from the proposed activities. If humpback and fin whales continue to use the Chukchi Sea and Beaufort Sea OCS program areas, seismic activities *may affect* small numbers of whales.

TAKE PRIDE IN AMERICA

Due to the low number of humpback and fin whales recently observed in the Arctic region and the required measures for protecting marine mammals, we conclude that any effects oil and gas leasing and exploration are negligible and are *not likely to adversely affect* either species.

MMS will continue to review sighting information from its OCS-operations and reassess the situation as necessary. The MMS will continue to encourage monitoring of humpback and fin whales movements and help the NMFS assess any long-term range extension, population abundance, stock origin, and distribution dynamics in OCS-program areas.

If you have any questions on the issues contained in this letter or require additional information, please contact me or Mr. Jeff Denton, Minerals Management Service, 3801 Centerpoint Drive, Suite 500, Anchorage, Alaska 99503-5823 (commercial and FTS telephone: 907-334-5262).

Sincerely,

Cleve Cowles, Ph.D.
Regional Supervisor
Office of Leasing and Environment

Attachment

cc:
Mr. Brad Smith
Anchorage Field Office
National Marine Fisheries Service
Federal Building
22 West Seventh Avenue, Box 43
Anchorage, Alaska 99513-7577

DRAFT
ATTACHMENT 1:

## Assessment of New Information-Humpback and Fin Whale Occurrence in the Chukchi and Beaufort Sea

Introduction:

Marine Mammal Observer (MMO) reports received by MMS for 2006 and 2007 OCS-related operations and other sources, summarized below, present recent occurrences of fin and humpback whales in the Arctic Beaufort and Chukchi Seas. Observations made by MMO personnel aboard vessels associated with OCS oil and gas activities are required by MMS and NMFS permit requirements. Unless otherwise noted, observations do not include other MMO data that may have been required by NMFS for other Arctic operations.

An MMO observation of three fin whales (including one calf) was reported in the Chukchi Sea in 2006.

In 2007, 28 humpback whales were recorded in 16 MMO observation records between August 8 and October 16 in the Chukchi Sea. Another set of observations reported at least three (including one calf) humpback whales in the Beaufort Sea on August 1, 2007.

### Analysis of Recent Sightings in Relation to the 2006 Arctic Regional Biological Opinion

Humpback Whales

Historically, humpback whales have not been observed during MMS annual Bowhead Whale Aerial Survey Project (BWASP) aerial surveys conducted during September and October in the Beaufort Sea from 1982-2007 (e.g., Monnett and Treacy, 2005; Moore et al., 2000; Treacy, 2002). No humpback observations occurred during MMS endangered whale surveys in July-October from north of St. Lawrence Island in the northern Bering Sea and the eastern Chukchi Sea conducted from 1979-1987 (Ljungblad, 1988).

The Arctic Regional Biological Opinion (ARBO) completed by NMFS on June 16, 2006, stated "While humpback whales could occur in the southern Chukchi Sea, they do not tend to occur further north and *are not expected to occur within the Chukchi Planning Area.* Humpbacks do not occur in the Alaskan Beaufort Sea." The recent humpback observations represent an affirmation of the "could occur in the southern Alaska Chukchi Sea" as well as now have occurred in the Beaufort Sea. The data remains insufficient and premature to determine population abundance or trends, consistent patterns of movement, habitat use, or stock of origin.

Current minimum population estimates for humpback whales in the NMFS 2006 Alaska Marine Mammal Stock Assessments indicate 367 for the Western North Pacific stock and 868 for the Central North Pacific stock. It is unknown which of these stocks the 2006 observed whales may originate.

Fin Whales

Historically, fin whales have not been observed during MMS annual Bowhead Whale Aerial Survey Project (BWASP) aerial surveys conducted during September and October in the Beaufort Sea from 1982-2007 (e.g., Monnett and Treacy, 2005; Moore et al., 2000; Treacy, 2002). One sighting of three fin whales (one calf) in the southern Chukchi Sea occurred in 1982 (Ljungbald, 1982).

The current ARBO accurately depicts the status of fin whales in the Arctic and indicated fin whales were rarely observed in the eastern half of the Chukchi Sea and have not been observed in the Alaskan Beaufort Sea. Specifically, the 2006 ARBO notes "within the Chukchi Sea, fin whales are more likely to occur near the Bering Strait, in the southwestern portion, along the coast of the Chukotka Peninsula, and are more likely in open water...*Fin whales are not expected to occur in the northeastern Chukchi Sea Planning area or in the Alaskan Beaufort Sea.*"

The single sighting of fin whales in the Chukchi Sea Planning Area is insufficient to determine any trend or consistent pattern of use. The observation confirms that although fin whales were not expected to occur in the northeast Chukchi Sea, they can, and in this case did, occur there. Current minimum population estimate for the northeast Pacific fin whale population west of the Kenai Peninsula is 5,703, including fin whales in the Bering Sea.

Conclusion

Recent humpback and fin whale observations in the OCS Chukchi Sea and Beaufort Sea Planning Areas represent new information that was not considered in the ESA Section 7 consultation that resulted in the Arctic Regional Biological Opinion (ARBO). That opinion stated,

> "Consultation will be re-initiated if...new information indicates these actions are impacting... other listed species... to a degree or in a manner not previously considered..."

As humpback and fin whales were not anticipated to occur in the either Chukchi Sea or Beaufort Sea Planning Areas (consolidated into the Arctic Region), MMS concluded there would be *no effect* on these species from the proposed activities. If humpback and fin whales continue to use the Chukchi Sea and Beaufort Sea OCS program areas, seismic activities *may affect* small numbers of whales.

MMS will continue to review sighting information from its OCS-operations and reassess the situation as necessary. The MMS will continue to encourage monitoring of humpback and fin whales movements and help the NMFS assess any long-term range extension, population abundance, stock origin, and distribution dynamics in OCS-program areas.

Due to the low number of humpback and fin whales recently observed in the Arctic region and the required measures for protecting marine mammals, we conclude that any effects oil and gas leasing and exploration are negligible and are *not likely to adversely affect* either species.

It is recommended that MMS reinitiate ESA consultation to solicit NMFS determination on required supplementation, if any, to the 2006 ARBO.

**Summary: 2006 and 2007 Humpback Whale Observations**

Chukchi Sea Planning Area

2006 MMO (MMS-related and Other Operations) Observations: None.

2007 MMO (MMS-related Operations) Observations:

August 8, 2007, the Gulf Provider MMO's reported two humpback whales (Gulf Provider Sighting ID # 73). The location is proprietary, but is confirmed to be in the Chukchi Sea Planning Area. Startup of seismic operations had not begun at the time.

September 9, 2007, humpback whales were reported by MMO's aboard the Gilavar (Gilavar Sighting ID #328). These sightings occurred when the Gilavar was apparently in a shutdown mode due to walrus in the exclusion zone around the vessel with the required mitigation gun operating. Nine sightings of two humpback whales were recorded shortly after the shutdown began. These sightings all occurred during a 63 minute period and it is uncertain whether repeated observations were made of the same two whales. Due to darkness and required verification that the safety area was clear of sea mammals, seismic operations did not resume until the following day, with the exception of the required mitigation gun. Locations are proprietary, but are confirmed to be in the Chukchi Sea Planning Area. Observations were made during the period of time that the Gilavar was conducting a geophysical program.

October, 15, 2007, MMO's on the Gilavar (Gilavar Sighting ID # 408) note two observations of 2 humpbacks and a single humpback. Both observations took place within approximately 9 minutes of each other and it is uncertain whether both observations were made of the same group. The Gilavar was in transit to/from Nome and the observations were 200 miles south of the Chukchi Sea Planning Area's southernmost boundary. Locations remain proprietary.

October 15, 2007, additional humpback whale sightings occurred ~90 miles south of the Chukchi Sea Planning Area southernmost boundary. Gilavar Sighting ID #410 reported a group of two humpback whales. Gilavar Sighting ID #411 reported two observations of a single humpback whale. The ID #411 sightings occurred within 12 minutes of one another and it is uncertain whether observations were made of the same whale. Specific locations remain proprietary.

October 16, 2007, one humpback whale was observed in the Chukchi Sea (Gilavar Sighting ID#415). This observation occurred in or immediately adjacent to the Chukchi Sea Planning Area. No geophysical operations were occurring at the time. Location remains proprietary.

2007 MMO (Other Operations) Observations: None.

November 21, 2007

Memorandum

To: Regional Supervisor, Leasing and Environment

Through: Chief, Environmental Assessment Section

From: Wildlife Biologist, EAS

Subject: 2007 Update for Humpback and Fin Whales in the Chukchi and Beaufort Seas

Please find attached a transmittal letter to National Marine Fisheries Service with attached assessment of new information regarding endangered fin and humpback whale occurrence in the Chukchi and Beaufort Seas for your concurrence and forwarding to the Regional Director.

Assessment of the 2006 and 2007 MMO observation information indicates observations of humpback whales dispersed over a wide region of the Arctic including the Chukchi Sea and Beaufort Sea Planning Areas and a presence from July to October of 2007.

One fin whale observation in 2006 supports the findings regarding this species in the existing June 16, 2006 Arctic Regional Biological Opinion (ARBO) from NMFS.

If humpback and fin whales continue to use the Chukchi Sea and Beaufort Sea OCS program areas, seismic activities *may affect* small numbers of whales. Due to the low number of humpback and fin whales recently observed in the Arctic region and the required measures for protecting marine mammals, we conclude that any effects oil and gas leasing and exploration are negligible and are *not likely to adversely affect* either species.

EAS staff recommends MMS send the attached cover transmittal letter and attachment to the Regional Director of NMFS in order to reinitiate ESA consultation to solicit NMFS determination on required supplementation, if any, to the 2006 ARBO.

## Schroeder, Mark

**From:** Sarah Conn/R7/FWS/DOI@FWS@DOI on behalf of Sarah Conn/R7/FWS/DOI@DOI
**Sent:** Wednesday, October 10, 2007 2:23 PM
**To:** Schroeder, Mark
**Subject:** Re: Species List for Chukchi and Beaufort Multiple Sale

Mark,

Thank you for your species list request pursuant to section 7 of the Endangered Species Act of 1973, as amended (Act). We understand the Minerals Management Service (MMS) is starting work on an Arctic multi-sale project. This action will lead to oil and gas leases being offered in both the Chukchi Sea and Beaufort Sea Outer Continental Shelf areas (Federal Register Vol. 72, No. 163, August 23, 2007).

The following species are managed under the Act by the Service, and may occur in the lease sale areas:

| Species | Status Under the Act |
|---|---|
| Steller's eiders (*Polysticta stelleri*) | Threatened |
| Spectacled eiders (*Somateria fischeri*) | Threatened |
| Polar bear (*Ursus maritimus*) | Proposed |
| Kittlitz's murrelet (*Brachyramphus brevirostris*) | Candidate |

The Service has been petitioned to list the Yellow-billed loon (*Gavia adamsii*), and MMS should be aware that the status of this species may change before completion of the proposed arctic lease sales.

Sarah Conn

Sarah C. Conn, PhD
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**Mark Schroeder/MMS/DOI@MMS**

10/02/2007 04:15 PM

To: Sarah Conn/R7/FWS/DOI@DOI
cc:
Subject: Species List for Chukchi and Beaufort Multiple Sale

Ms. Conn:

# APPENDIX I

# ENVIRONMENTAL STUDIES

# MMS Alaska OCS Region
# Environmental Studies Program

The Minerals Management Service (MMS) Environmental Studies Program (ESP) was established and funded by the United States Congress to support the offshore oil and gas leasing program of the U.S. Department of Interior (USDOI) in pursuit of national energy policies. Administered originally in 1973 by the Bureau of Land Management, then by the Minerals Management Service since 1982, the consistent mandate of the ESP has been to establish the information needed for assessment and management of potential impacts from oil and gas development on the Outer Continental Shelf and coastal environments.

The Outer Continental Shelf Lands Act (OCSLA) of 1953, as amended [Public Law 95-372, Section 20], provide guidelines for balancing orderly energy resource development with protection of the human, marine, and coastal environments. The basic agency mission is to expedite mineral resource exploration and development at fair market value in a safe and environmentally responsible manner. Also, the National Environmental Policy Act (NEPA) of 1969 requires that all Federal Agencies use a systematic, interdisciplinary approach that will ensure the integrated use of the natural and social sciences in any planning and decision making that may have effects on the environment. Federal laws impose additional requirements on the offshore leasing process, including the Coastal Zone Management Act; Federal Water Pollution Control Act Amendments; Marine Mammal Protection Act (MMPA); Endangered Species Act (ESA); and Marine Protection, Research and Sanctuaries Act.

The MMS Environmental Studies Program operates on a national scale to assist in predicting, projecting, assessing and managing potential effects on the human, marine and coastal environments of the OCS that may be affected by oil and gas development. Lease-management decisions are enhanced when current, pertinent and timely information is available. Since the ESP began, the Department of the Interior and the MMS has funded nationally more than $800 million on environmental studies through fiscal year 2008. More than $300 million of that amount has funded studies in Alaska across 15 planning areas in the Arctic, Bering Sea and Gulf of Alaska sub-regions to produce more than 400 different study reports. The ESP currently manages more than 50 ongoing study projects in Alaska in disciplines such as physical oceanography, fate and effects of pollutants, protected and endangered species, wildlife biology, and the social sciences. These studies are listed at the end of this section. Completed study reports are posted on the Alaska OCS Region website at http://www.mms.gov/alaska/ref/AKPUBS.HTM.

Early in the development of the program, the focus was on obtaining baseline information on the vast biological resources and physical characteristics of the Alaskan environment for pre-lease decision making. These studies included biological surveys of marine species, basic oceanography and meteorology, and geologic and sea ice phenomena. As a broader base of information was established, it became possible to focus on more topical studies in smaller areas to answer specific questions and fill identified information needs. In addition, generic studies were initiated to examine the potential effects of oil spills on biological resources, and different scenarios were developed to determine the most likely routes of transport and dispersion of oil that might affect the marine environment.

As study efforts collected and analyzed more disciplinary data, the importance of taking an integrated, interdisciplinary look at complete ecosystems in sensitive areas became apparent. During this time, the offshore leasing program was maturing. As a number of sales were held and

exploration activities began, post-lease studies to monitor some of the possible effects of oil and gas activities on the environment and resources of these areas were initiated.

The use of computer models, such as the MMS Oil-Spill-Risk Analysis (OSRA), has been implemented to aid in the assessment of potential oil spill and other pollutant risks to the environment and to key species such as fur seals, sea otters and endangered whales. Modeling has also been used in the ecosystem studies, especially where extrapolation to other areas provided valid analysis.

As studies information has been amassed, improved focus has required greater integration of various scientific disciplines. The MMS has initiated Synthesis Meetings, Information Transfer Meetings (ITMs) and Information Update Meetings (IUMs) to gather maximum expertise and assess the status of existing information, as well as to plan the best possible approach to a study within the constraints of time and resources. As the MMS and other Federal and State agencies collect more pertinent information, the MMS funds studies to search and evaluate existing literature and data prior to initiation of field efforts. This prevents duplication of effort and saves valuable resources by focusing study efforts on the areas of greatest information need and highest usefulness to MMS decision needs.

In 2004, the U.S. Commission on Ocean Policy (USCOP) noted that "the MMS Environmental Studies Program (ESP) is a major source of information about the impacts of OCS oil and gas activities on the human, marine, and coastal environments" (USCOP, 2004). However, the Alaska ESP has been challenged to meet its mission in an increasingly conservative fiscal environment. Despite this challenging situation, the ESP, at the national level and in all the regions including Alaska, remains committed to attaining quality environmental information.

## Strategy of the Alaska ESP

To be responsive to ongoing leasing plans and changing offshore technologies, the Alaska OCS Region continually proposes new studies and pursues information needs in conjunction with ESP goals. Studies planning is a year-long process. In a frontier region such as the Alaska OCS Region, planning lead-time is necessary to conduct adequate environmental studies. Challenges include: large and remote planning areas, diverse and extreme environmental conditions, still-evolving hydrocarbon extraction technology, and potential environmental hazards associated with offshore activities.

At each step of the offshore leasing and development process, a variety of potential issues or resource-use conflicts may be encountered. Two questions are fundamental:

- What is the expected change in the human, marine and coastal environment due to offshore activity?

- Can undesirable change be minimized by mitigating measures?

Environmental studies are the primary means to provide information on these questions for use by decision makers. The ESP provides information that is useful for development of the 5-year leasing schedule and for pre-lease and lease-related decisions, and develops monitoring information useful in post-lease management.

The ESP utilizes a continuing process to synthesize information from many projects into a broader, multi-disciplinary view of research results. Of particular importance is the sharing of information among scientific fields. Efforts such as MMS-sponsored ITMs have helped the Alaska Region guide the design of future studies toward a more encompassing involvement of local and traditional information with scientific activities. Local and traditional knowledge has been incorporated into specific study planning, fieldwork, and interpretation of results over the years of the ESP. In MMS field-oriented studies, researchers typically coordinate directly with local communities to discuss their plans, seek advice and assure that interested individuals learn about the project and its results. The process of melding local and traditional knowledge varies from project to project, but the outcome of better information for decision making is a common goal. The ESP also supports publication of study results in peer-reviewed literature, which improves the quality of study reports and increases the availability of study results to a wide audience.

Currently, a major portion of the Alaska ESP is conducted on a collaborative basis. In 1993 MMS developed the Coastal Marine Institute (CMI) to take advantage of scientific expertise at the local level in addressing issues of mutual concern. The Alaska CMI represents a unique cooperative effort between the MMS, the University of Alaska, and the State of Alaska to engage a diverse range of non-Federal entities in the joint pursuit of sound environmental scientific research. The Alaska ESP also coordinates with many U.S. and local agencies, academic institutions, industry programs and other research entities. Additional international linkages with other arctic nations' research and regulatory entities have also been established. The U.S. and seven other arctic nations voluntarily agreed to cooperate on an Arctic Environmental Protection Strategy, which evolved into the formation of the Arctic Council in 1996. The Alaska ESP has coordinated with Arctic Council activities, such as the Arctic Monitoring and Assessment Program, Conservation of Arctic Flora and Fauna, Arctic Climate Impact Assessment and others.

## Pre-lease Considerations

ESP planning reflects consideration of the proposed lease sales in the *Final Outer Continental Shelf Oil and Gas Leasing Program 2007-2012* (USDOI, MMS, 2007). The first lease sale under this *Program* was held in February 2008 in the Chukchi Sea Planning Area. The *Final Program* also proposes two sales in the Beaufort Sea (2009 and 2011) and two more sales in the Chukchi Sea (2010 and 2012), one sale in the North Aleutian Basin (2009) and two sales in Cook Inlet if industry expresses interest.

Preparation of the Environmental Impact Statement (EIS) is an essential part of the pre-lease process that requires environmental information. In particular, information is needed in time to prepare draft EIS's for proposed lease sales. Although much information exists for certain Alaska OCS lease areas, data are sparse in other areas. In addition, changing conditions and environments often lead to the need to update past studies so that EIS information is current and accurate.

As proposals for exploration and development continue to evolve, Alaska's coastal communities expect increased involvement in project reviews and decisions that may affect their subsistence lifestyle. Since the people of Alaska's remote arctic and sub arctic communities rely so heavily on subsistence resources of the marine environment, they are especially concerned about industrial activities that may directly or indirectly affect hunting success or the habitats of the species important to subsistence. Many other related issues potentially could be affected by OCS activities, such as the well-being of marine mammals and threatened and endangered species. Coastal residents of Alaska have concerns about these resources, as do State and Federal agencies responsible for their management by law.

## Post-lease Considerations

Prior to fiscal year (FY) 1982, most studies of the Alaskan offshore were planned, conducted, and concluded before a sale was held in order to provide information for decision making and EIS's. However, not all needed information can be obtained prior to a sale. In accordance with mandates of Section 20 of the OCSLA, as amended, post-lease studies are also needed to address environmental concerns and monitoring related to specific developments. The MMS acquires additional information for environmental analyses related to development and production in the post-lease phase. Thus, an increasing number of studies have become more closely related to development schedules and monitoring and evaluation in addition to those broader studies related to the pre-lease phase. As with the pre-lease phase, the wide range of environmental conditions from Cook Inlet to the Arctic is accounted for in the process of formulating new studies. Post-lease activities that require environmental data and assessment include:

- Geophysical surveys
- Exploration Plans
- Exploration drilling
- Development and Production Plans
- Development, construction and production activities
- Oil transportation, including pipelines and tankers
- Platform decommissiong

In the Beaufort Sea Planning Area, there have been 929 tracts leased in ten OCS Lease Sales. Industry has drilled 31 exploratory wells and determined 11 to be producible. Lease Sale 193 in

February 2008 resulted in 486 leases being issued in the Chukchi Sea Planning Area. The only other active leases are in the Cook Inlet/Shelikof Strait Planning Area.

The ESP information is used in numerous specific decisions, including selection of areas for leasing consideration, decisions to lease, EIS development and post-lease assessment, exploration monitoring, mitigation, permit evaluations and others.

## Identification of Information Needs

The Alaska ESP distributes the *Alaska Annual Studies Plan* for the coming fiscal year to more than 200 Federal, State, local, environmental, Native, industry, international and other stakeholders each autumn. A letter is also distributed to the same stakeholders requesting suggestions for new studies for the following year. In addition, suggestions for new studies are solicited from all components of the Alaska OCS Region staff.

The ESP also relies heavily on information needs identified through solicitation of public comment and suggestions on how to enhance our information base at ITMs and other meetings. For example, the Alaska OCS Region has conducted ten ITMs. The tenth ITM was convened in Anchorage, Alaska, in March 2005 in Anchorage, Alaska. A Beaufort Sea IUM was also held in March 2005 in Barrow, Alaska. In addition, the MMS has sponsored a number of workshops and conferences over the years with topics that include: the use of high frequency radar to map surface currents; various aspects of physical oceanography; arctic cisco in the Beaufort Sea; and social and economic impacts associated with oil and gas development. The meetings, which were attended by experts in the respective fields and other interested stakeholders, identified information needs and recommended studies to support the MMS mission.

In preparation for possible oil and gas exploration in the Chukchi Sea, the MMS Alaska OCS Region conducted a three day *Chukchi Offshore Monitoring in Drilling Area* (COMIDA) planning workshop November 1-3, 2006, in Anchorage. The purpose of the workshop was to identify potential monitoring tasks for a FY 2008 COMIDA field effort to meet MMS needs. Invitations were sent to over 150 scientists and stakeholders, including local and regional governments, tribes, native associations, oil industry and environmental groups. Over 100 scientists and stakeholders attended. Thirteen monitoring study profiles were developed by four working groups, presented to and discussed by the workshop participants, and submitted to the MMS for prioritization for inclusion in the COMIDA field effort. In total, the agency received 15 study profiles on the various topics discussed.

Currently, a number of organizations and government agencies are sponsoring (along with the MMS) the *United States and Canada Northern Oil and Gas Research Forum: Current Status and Future Directions in the Beaufort Sea, North Slope and Mackenzie Delta*, to be held October 28-30, 2008. This forum will focus on oil and gas related research in the Beaufort Sea. It will provide an opportunity to share research, identify synergies and build on existing partnerships. Concurrent with this meeting, the MMS Alaska OCS Region is planning to hold its eleventh ITM.

The following sections summarize the goals of ongoing and proposed studies in each discipline:

**Physical Oceanography:** An ongoing challenge in the Alaska OCS Region is the need for better, finer scale circulation and oil-spill models and higher resolution data for the nearshore portions of the Beaufort and Chukchi Seas. Development and application of state-of-the-art circulation models are essential to future OSRA-based EIS analyses. The MMS has partnered

with the National Ocean Partnership Program to produce high-resolution circulation models covering Arctic OCS waters.

Improvements are also needed in sea ice aspects of the modeling. The resolution of ice models and ice data needs to be increased to address the propagation of fine scale non-random interactions across hundreds of miles of pack ice in the case of ice leads, as evidenced by recent improvements in satellite oceanography. The MMS and the National Aeronautics and Space Administration (NASA) have partnered with an international, industry/academic team to create a new state-of-the-art ice model, sufficient to resolve the spectrum of ice thickness, evolution, and motion in transition from thin new ice to thick ridged ice to landfast ice.

The accuracy of surface wind fields, ocean currents, and information regarding the spatial and temporal variability of polynyas, leads, and landfast ice are important for determining the fate of spilled oil in this region and the impacts on biota associated with these systems. The MMS studies have demonstrated that landfast ice completely blocks wind forcing of under-ice waters. Thus water moves differently under landfast ice than adjoining open or pack ice waters. It becomes very important to know locations of and seasonal changes in the distribution of landfast ice. The MMS recently completed a study on leads and landfast ice which updated our information for the Beaufort Sea and a portion of the Chukchi Sea.

Current and proposed keystone studies include:

- Beaufort Sea Nearshore Currents
- Surface Circulation Radar Mapping in Alaskan Coastal Waters: Field Study Beaufort Sea and Cook Inlet
- Sea Ice Modeling for Nearshore Beaufort and Chukchi Seas
- Beaufort Sea Mesoscale Meteorology
- Mapping and Characterization of Recurring Polynyas and Landfast Ice in the Chukchi Sea
- Surface Current Circulation High Frequency (HF) Radar Mapping in the Chukchi Sea
- Physical Supporting Data for Chukchi Offshore Monitoring in Drilling Area

**Fate and Effects:** North Slope villagers are concerned about potential effects on their food supply. In the Beaufort Sea such foods include bowhead whales, seals, waterfowl and fish. Of particular concern are environmental effects of development on these biota, including those from potential oil spills. Related to these concerns, additional information is needed regarding currents that might carry oil under ice. Additional information on ocean currents and sea ice is necessary to fully address these concerns. Information on the fate (weathering) of oil spills is being obtained through participation with an a joint industry consortium doing field experiments on cleanup, behavior, and weathering of oil in broken ice.

The Alaska OCS Region has collected baseline biological and chemical monitoring data in the vicinity of the Liberty Prospect and Northstar since 1999, as part of the studies “Arctic Nearshore Impact Monitoring in the Development Area” (ANIMIDA) and “Continuation of Arctic Nearshore Impact Monitoring in the Development Area” (cANIMIDA). The summer of 2007 was the last field season for the current cANIMIDA project. The objectives of cANIMIDA include:

- Hydrocarbon and metal characterization of sediments, bivalves and amphipods in the study area

- Annual assessment of subsistence whaling near Cross Island
- Identification of sources, concentrations, and dispersion pathways for suspended sediment
- Monitoring the "Boulder Patch" kelp community
- Characterization of anthropogenic contaminants in upper trophic biota
- Partitioning of potential contaminants between dissolved and particulate phases

Two of these monitoring tasks are currently planned to extend beyond the cANIMIDA project. Because of lack of observed effects, however, other cANIMIDA tasks will undergo a hiatus prior to reconsideration, unless new Beaufort Sea OCS development occurs sooner than expected.

In addition to site-specific monitoring, ANIMIDA and cANIMIDA re-examined the regional pollutant levels in the U.S. Beaufort Sea. The MMS set up the Beaufort Sea Monitoring Project (BSMP) in the 1980s to monitor sediment quality. The BSMP monitored trace metal and hydrocarbon levels in sediments and benthic biota at specific locations on a regional basis. The ANIMIDA and cANIMIDA projects have resampled many of the BSMP stations from Harrison Bay to Camden Bay and Coastal Marine Institute studies resampled BSMP areas further west (Point Barrow) and east (Beaufort Lagoon).

The 2006 COMIDA workshop described the importance of benthos and chemical monitoring to evaluate the health of the Chukchi ecosystem. The MMS Scientific Committee recommended an adaptive initial two-year sampling program that closely coordinated separate chemical and benthos monitoring efforts. The study "COMIDA: Chemistry and Benthos (CAB)" combines those two efforts and will start field work in 2009.

**Protected Species:** Production at the Northstar site and at other potential sites may lead to risks of oil spills from buried pipelines, other discharges, noise from various industrial and support activities and increased human interaction with arctic offshore species. Species protected under the ESA, MMPA and the Migratory Bird Treaty Act are of particular concern if impacted by such factors. Study of the effects of oil and gas-related activities on protected mammals and the need for continued monitoring of endangered species are ongoing.

The MMS has conducted the aerial surveys of the fall migration of bowhead whales each year since 1987, known as the Bowhead Whale Aerial Survey Project (BWASP). Methods are comparable from year to year, based on similar monitoring dating to 1979. Real-time data are used to implement overall seasonal restrictions and limitations on geological and geophysical exploration. The study provides the only long-term database for evaluating potential cumulative effects of oil- and gas-exploration activities on the entire bowhead-migration corridor across the Alaskan Beaufort Sea.

Iñupiat whale hunters rely heavily on bowhead whales for subsistence. The bowhead whale is central to village cultural and spiritual life. Whale hunters have reported that migrating bowhead whales deflect from their normal migratory route well upstream of active industry vessels and may divert their migration route. A concern is that deflection around oil and gas-industry activity (including drilling activity and associated icebreaker support) makes whales skittish and more difficult to hunt. Bowhead whales also feed along the fall migration route and information about bowhead feeding and habitat use is needed. Noise from industrial activity is a central concern. Additionally, Iñupiat whale hunters and the scientific community have raised concerns about potential cumulative impacts on bowhead whales. It is important to assess the factors that may be affecting the habitat use, health, population status and migration routes of bowhead whales.

Future bowhead studies are expected to continue to explore use of satellite tagging for information on bowhead whale residence times in development areas and information on bowhead behavior in response to industrial noise.

Effects of construction activities on polar bears, especially on denning bears, and concerns about the adequacy of information about all age/sex categories of the bear population will need to be addressed by additional research. Several ongoing studies are expected to lead to recommendations for additional information regarding polar bears and continued study of the bear population's vulnerability to oil spills through improved models.

The populations of bowhead whales, polar bears, beluga whales, spectacled eiders and other endangered species are an ongoing concern of environmental groups, Federal agencies and others. North Slope villages are also concerned about potential disturbance of ringed seals, waterfowl and other subsistence-wildlife species by oil industry activities such as helicopter overflights. The status of many animal populations may also have changed since earlier studies were conducted. Climate change may have triggered many spatial and temporal changes in the distribution of a variety of species. It will be important for the MMS to continue post-lease monitoring studies and other priority studies of key species and marine communities in the Beaufort and Chukchi Seas.

These concerns are addressed in part by a number of ongoing and proposed studies including:

- Monitoring the Distribution of Arctic Whales, also known as BWASP
- Distribution and Relative Abundance of Marine Mammals: Aerial Surveys
- Bowhead Whale Feeding Variability in the Western Alaskan Beaufort Sea
- Population and Sources of Recruitment in Polar Bears
- Monitoring the Health of Bowhead Whales
- Pinniped Movements and Foraging
- Monitoring Marine Birds of Concern in the Eastern Chukchi Nearshore Area (Loons)
- Passive Acoustic Detection and Monitoring of Endangered Whales in the Arctic
- Demography and Behavior of Polar Bears Summering on Shore in Alaska
- Migration and Habitat Use by Threatened Spectacled Eiders in the Eastern Chukchi Near and Offshore Environment

**Fisheries:** The MMS needs information to assess and manage the potential environmental effects of offshore development on marine fish. Little is known about the biology and ecology of many marine fish species inhabiting the Alaska lease areas. The highest priority MMS information needs include species presence, distribution, abundance and potential effects of oil spills, particularly during periods when ice is present. As offshore oil development interest expands to deeper and more widespread areas, additional fisheries information is required.

As a result of the Magnuson Fishery Conservation and Management Act, effects on Essential Fish Habitat must be evaluated in NEPA analyses. The Bering Sea and the North Aleutian Basin support the most important commercial fisheries in the U.S. More information is required to evaluate Essential Fish Habitats in the Chukchi Sea as commercial fish species move northward. Beaufort waters are also considered Essential Fish Habitat for salmon, and future research on salmonid reproduction in Beaufort Sea drainages is indicated to clarify environmental assessment and mitigation needs.

Residents and non-residents dependent on commercial fisheries are concerned about development activities interfering with those fisheries. Even the simple public perception of tainting of commercial fish could cause detrimental effects on commercial fish markets for years to come. Alaska Native villagers are also concerned that OCS activities will affect subsistence fish populations and reduce subsistence utilization. Thus, additional research on arctic fisheries and recruitment to nearshore feeding populations should be considered. Several fish species used for subsistence migrate through, or are found in, the Northstar and Liberty areas of the Beaufort Sea, including arctic and least cisco, Dolly Varden, arctic char, and humpback and broad whitefish. Intermittent occurrences of pink and chum salmon also take place in Beaufort coastal waters.

Information on the forage fish resources and their relation to apex predators in the Bering, Chukchi and Beaufort Seas is also indicated. A good understanding of the seasonal distribution, abundance and habitat use of forage fish, including key spawning and migration events that quickly transfer large amounts of energy to upper trophic levels, is fundamentally important to monitoring the potential environmental impacts associated with offshore development at all trophic levels.

Studies that address these issues include:

- Current and Historic Distribution and Ecology of Demersal Fishes in the Chukchi Sea Lease Area
- Spatial and Seasonal Distribution and Abundance of the Forage Fish Prey Resource of Chukchi Marine Mammals and Birds

**Social Science and Economics:** Residents of the North Slope coastal communities frequently express concern about cumulative impacts of offshore and onshore developments on their subsistence lifestyle. Relative to existing oil and gas operations, the villages of most pressing concern are Kaktovik, Nuiqsut and Barrow. Consideration of cumulative impacts is an increasingly important issue for the MMS in preparing NEPA documents. Some of the concerns of the Iñupiat include diminished access to hunting and fishing areas around oil industry infrastructure, reduced harvests, increased hunter efforts and increased hunter cost. How, and to what degree, subsistence activities have been affected by industry infrastructure and industry activity is a concern that may be addressed by additional research.

There is an ongoing need to monitor key indicators of socioeconomic and cultural changes on the North Slope. The Iñupiat rely on a wide variety of marine resources as significant sources of food. In addition, the harvesting, sharing and consuming of subsistence resources form an important part of the traditional Iñupiaq culture and spiritual life. People are concerned that a temporary or permanent elimination of primary subsistence foods would cause North Slope residents either to shift to less desired subsistence resources or to replace subsistence foods with expensive Western foods. The Iñupiat are concerned about mitigation, including compensation for potential losses. An anticipated decline in oil revenues to the North Slope Borough is an issue of concern also. Another concern is the use of local and traditional knowledge in analysis of potential environmental effects. We continue to seek and include firsthand knowledge of local subsistence hunters to augment the scientific knowledge base.

Ongoing and proposed studies that address these concerns include:

- Subsistence Mapping of Nuiqsut, Kaktovik and Barrow: Past and Present Comparison

- Study of Sharing Networks to Assess the Vulnerabilities of Local Communities to Oil and Gas Development Impacts in Arctic Alaska
- Continuation of Impact Assessment for Cross Island Whaling Activities
- Aggregate Effects Research and Environmental Mitigation Monitoring of Oil Operations in the Vicinity of Nuiqsut
- Impact Monitoring for Offshore Subsistence Hunting

## Current Alaska OCS Region studies that will support analysis of the proposed Arctic Lease Sales and subsequent activities

### Physical Oceanography

- Beaufort Sea Nearshore Currents
- Feasibility and Study Design for Boundary Oceanography of the Beaufort Sea
- Beaufort Sea Mesoscale Meteorology
- Mapping Sea Ice Overflood Using Remote Sensing from Smith Bay to Camden Bay
- Sea Ice Modeling for Nearshore Beaufort and Chukchi Seas
- Support of the Collection of Meteorological Data on the North Slope and Beaufort Sea, Alaska
- Surface Circulation Radar Mapping in Alaskan Coastal Waters: Field Study Beaufort Sea and Cook Inlet
- Idealized Process Model Studies of Circulation in the Landfast Ice Zone of the Alaskan Beaufort Sea

### Fates and Effects

- Chukchi Sea Offshore Monitoring in Drilling Area (COMIDA): Chemistry and Benthos (CAB)
- Updates to the Fault Tree Approach to Oil-Spill Occurrence Estimators for the Chukchi and Beaufort Sea Planning Areas
- Assessment of the Direction and Rate of Alongshore Transport of Sand and Gravel in the Prudhoe Bay Region, North Arctic Alaska
- Synthesis of Time-Interval Changes in Trace Metals and Hydrocarbons in Nearshore Sediments of the Alaskan Beaufort Sea: A Statistical Analysis

### Biology

- Current and Historic Distribution and Ecology of Demersal Fishes in the Chukchi Sea Lease Area
- Arctic Fish Ecology Catalogue
- Testing Molecular and Otolith Tools to Investigate Population-of-Origin and Migration in Arctic Cisco Found in the Colville River, Alaska
- Beaufort Sea Marine Fish Monitoring: Pilot Survey and Test of Hypotheses
- Foraging Ecology of Common Ravens on Alaska's Coastal Plain

### Protected Species

- COMIDA: Distribution and Relative Abundance of Marine Mammals: Aerial Surveys
- Satellite Tracking of Walruses in the Chukchi Sea: The Planning Phase
- Monitoring the Distribution of Arctic Whales
- Bowhead Whale Feeding Variability in the Western Alaskan Beaufort Sea: Satellite Tracking of Bowhead Whales
- Bowhead Whale Feeding Variability in the Western Alaskan Beaufort Sea: Oceanography and Feeding
- Aerial Photography of Bowhead Whales to Estimate the Size of the Bering-Chukchi-Beaufort Population
- Populations and Sources of Recruitment of Polar Bears
- Radio-Frequency Identification Tags for Grizzly and Polar Bear Research
- Pinniped Movements and Foraging

- Assessing Reproduction and Body Condition of the Ringed Seal near Sachs Harbour, Northwest Territory, Canada, through a Harvest-based Sampling Program
- Pre-migratory Movements and Physiology of Shorebirds Staging on Beaufort Sea Littoral Zone
- Monitoring Marine Birds of Concern in the Eastern Chukchi Nearshore Area (Loons)

**Social Science and Economics**

- COMIDA: Impact Monitoring for Offshore Subsistence Hunting
- Continuation of Impact Assessment for Cross Island Whaling Activities
- Traditional Knowledge Regarding Bowhead Whales in the Chukchi Sea
- Subsistence Mapping at Nuiqsut, Kaktovik, Barrow, and Wainwright: Past and Present Comparison
- Researching Technical Dialogue with Alaskan Coastal Communities: Analysis of the Social, Cultural, Linguistic, and Institutional Parameters of Public/Agency Communication Patterns
- Study of Sharing Networks to Assess the Vulnerabilities of Local Communities to Oil and Gas Development Impacts in Arctic Alaska
- Social and Economic Assessment of Major Oil-Spill Litigation Settlement for the Alaska OCS Region

**Multidisciplinary**

- Continuation of Arctic Nearshore Impact Monitoring in Development Area (cANIMIDA): Core Contractor Program Management, Logistics, Data Management and Reporting
- Continuation of Arctic Nearshore Impact Monitoring in Development Area (cANIMIDA): Hydrocarbon and Metal Characterization of Sediments in the cANIMIDA Study Area
- Continuation of Arctic Nearshore Impact Monitoring in Development Area (cANIMIDA): Sources, Concentrations, and Dispersion Pathways for Suspended Sediment in the cANIMIDA Study Area
- Continuation of Arctic Nearshore Impact Monitoring in Development Area (cANIMIDA): Partitioning of Potential Contaminants between Dissolved and Particulate Phases in the cANIMIDA Study Area
- Continuation of Arctic Nearshore Impact Monitoring in Development Area (cANIMIDA): Integrated Biomonitoring and Bioaccumulation of Potential Anthropogenic Contaminants in Biota of the cANIMIDA Study Area
- Continuation of Arctic Nearshore Impact Monitoring in Development Area (cANIMIDA): Monitoring the 'Boulder Patch' as part of the cANIMIDA Program
- Continuation of Arctic Nearshore Impact Monitoring in Development Area (cANIMIDA): Continuation of Annual Assessment of Subsistence Bowhead Whaling near Cross Island and part of the cANIMIDA Project

**Other**

- Minerals Management Service/University of Alaska-Fairbanks/State of Alaska/Coastal Marine Institute – Management (All Alaska Planning Areas)
- Alaska Marine Science Symposium (All Alaska Planning Areas)
- Management, Logistics, and Warehouse Storage of Oceanographic Equipment (All Alaska Planning Areas)
- Conference Management and Reports on MMS Results (All Alaska Planning Areas)

## National Oceanography Partnership Program (NOPP)

- Circulation, Cross-Shelf Exchange, Sea Ice, and Marine Mammal Habitats on the Alaskan Beaufort Sea Shelf
- Toward a predictive model of Arctic coastal retreat in a warming climate, Beaufort Sea, Alaska
- Episodic Upwelling of Zooplankton within a Bowhead Whale Feeding Area near Barrow, AK
- Comprehensive Modeling Approach Towards Understanding and Prediction of the Alaskan Coastal System Response to Changes in an Ice diminished Arctic

## Alaska OCS Region Research Partnerships

- MMS Technology Assessment and Research Program (TAR)
- MMS-University of Alaska Fairbanks-State of Alaska Coastal Marine Institute (CMI)
- Cooperative Ecosystem Studies Unit (CESU); University of Alaska Fairbanks (UAF); University of Washington (UW)
- USGS/Biological Resources Division (BRD)
- National Oceanographic Partnership Program (NOPP);
- Federal Inter-agency Agreements: eg. NOAA-National Marine Fisheries Service (NMFS) / National Marine Mammal Laboratory (NMML)
- National Science Foundation (NSF)
- North Slope Science Initiative (NSSI)
- North Pacific Research Board (NPRB)
- National Aeronautics and Space Administration (NASA)
- National Fish and Wildlife Foundation (NFWF)
- Cold Regions Research Engineering Laboratory (CRREL) (U.S. Army Corps of Engineers)
- Alaska Ocean Observing System (AOOS)
- Alaska Department of Fish and Game (ADF&G)
- Arctic Council - Arctic Monitoring and Assessment Program (AMAP)
- Canadian Department of Fisheries/Oceans (DFO)
- Industry Studies

## ACRONYMS

| | |
|---|---|
| ADF&G | Alaska Department of Fish and Game |
| ANIMIDA | Arctic Nearshore Impact Monitoring in Development Area |
| AOOS | Alaska Ocean Observing System |
| BRD | Biological Resources Division (USGS) |
| BSMP | Beaufort Sea Monitoring Program |
| BWASP | Bowhead Whale Aerial Survey Project |
| CAB | Chemistry and Benthos |
| cANIMIDA | Continuation of Arctic Nearshore Impact Monitoring in Development Area |
| CESU | Cooperative Ecosystem Studies Unit |
| CMI | Coastal Marine Institute |
| COMIDA | Chukchi Offshore Monitoring in Drilling Area |
| CRREL | Cold Regions Research Engineering Laboratory (U.S. Army Corps of Engineers) |
| DFO | Canada Department of Fisheries Oceanography |
| EIS | Environmental Impact Statement |
| ESA | Endangered Species Act |
| ESP | Environmental Studies Program (refers to MMS national program) |
| FY | Fiscal Year |
| HF | High Frequency |
| ITM | Information Transfer Meeting |
| IUM | Information Update Meeting |
| MMPA | Marine Mammal Protection Act |
| MMS | Minerals Management Service |
| NAB | North Aleutian Basin |
| NASA | National Aeronautics and Space Administration |
| NEPA | National Environmental Policy Act |
| NFWF | National Fish and Wildlife Foundation |
| NMFS | National Marine Fisheries Service |
| NMML | National Marine Mammal Laboratory |
| NOAA | National Oceanic and Atmospheric Administration |
| NOPP | National Oceanographic Partnership Program |
| NPRB | North Pacific Research Board |
| NSSI | North Slope Science Initiative |
| NSF | National Science Foundation |
| OCS | Outer Continental Shelf |
| OCSLA | Outer Continental Shelf Lands Act |
| OSRA | Oil-Spill-Risk Analysis |
| TAR | Technology Assessment and Research Program |
| UAF | University of Alaska-Fairbanks |
| USCOP | U.S. Commission on Ocean Policy |
| USDOI | U.S. Department of the Interior |
| USGS | U.S. Geological Survey |
| UW | University of Washington |

## Literature Cited

USCOP. 2004. *An Ocean Blueprint for the 21st Century*. Final Report of the U.S. Commission on Ocean Policy to the President and Congress. Washington, DC., 624 pp.

USDOI, MMS. 2007c. *Final Outer Continental Shelf Oil and Gas Leasing Program 2007-2012*. Herndon, VA.

# APPENDIX J

# PUBLIC HEALTH

**NOTICE TO READER – The contents of Appendix J were authored by the North Slope Borough, Alaska, via a Memorandum of Understanding with the Minerals Management Service shortly before this DEIS went to print.**

**Due to structural changes in this DEIS a substantial number of the numeric references contained in Appendix J that refer to other portions of this document may not be accurate. This Appendix will be re-written prior to publishing the Final EIS (FEIS).**

The MMS and the North Slope Borough (NSB) established a Memorandum of Understanding for the NSB to provide information on public health for use in the Arctic Multiple-Sale EIS. The health effects analysis was undertaken by Aaron Wernham, MD, MS, ANTHC; Project Director, as consultant to the North Slope Borough (NSB). This appendix presents NSB's evaluation of public health impacts, along with mitigation measure suggested by NSB and Dr. Wernham. The appendix also includes a brief description of the method used for the human health description and analysis. A list of information sources and a list of limitations on the assessment are provided. The MMS has incorporated some of the health effects information into the Environmental Justice sections. Additional health impacts information may be incorporated into the Final EIS. The proposed mitigation measures are still under consideration. The MMS and NSB have agreed to a series of work sessions to discuss these measures.

## Information Sources

The analysis of health effects in this assessment draws on the following sources of information:

a. Public testimony during scoping hearings;
b. Published peer-reviewed public health data;
c. Public health databases and monitoring programs;
d. Interviews with stakeholders;
e. Professional opinion; and
f. Impacts discussed in other subsections of the EIS, such as Air Quality and Subsistence.

## Methodology

The public health analysis draws on the methods of "Health Impact Assessment." A current description of the principles and process of HIA was recently published by the International Association of Impact Assessment (IAIA, 2007). The International Finance Corporation (IFC) published Performance Standards for Community Health, Safety, and Security in 2006, and in 2007 released updated Guidance Notes for this Standard. Previous work on the North Slope has employed a similar approach, adapted to NEPA (Wernham, 2007; Bhatia, R. and Wernham, A., 2008). Aspects of these approaches have been adapted for use in the assessment.

The World Health Organization uses a general categorization of health (communicable diseases, non-communicable diseases, accidents and injuries, malnutrition, psychosocial disorder, and social well-being), and tends to view health effects broadly, evaluating the social, economic, and environmental factors that can influence health. The IFC and International Association of Oil and Gas Producers have suggested a similar approach, but one which is tied more directly to environmental sectors that can be affected by large projects (as defined by the World Bank), including housing, water and food, transportation, and communication and information management. Health effects are then assessed across these environmental categories to create a series of Environmental Health Areas, or categories of health effect tied to environmental changes associated with the project being evaluated. The classification of environmental changes used by the IFC includes (a) Influx (population change related to the project); (b) Resettlement and relocation; (c) Water management; (d) Linear features (roadways, transportation routes, transmission lines); (e) Hazardous materials control and disposal; (e) Changes in income and expenditure (including inflation).

The scope of health effects was determined through evaluating: (1) prevalent illnesses, health disparities and vulnerabilities in the NSB population; (2) projected impacts on resource areas that might affect health (socioeconomics, subsistence, community infrastructure and services, subsistence, air quality, and water quality); (3) public testimony; and (4) accepted mechanisms of health and illness. The evaluation was used to generate a general categorization of health issues relevant to the propose actions addressed in this EIS. This categorization is an adaptation of that put forth by the IFC, tailored to include important health issues, likely areas of impact, and community concerns (Table 1).

The "Description of the Affected Environment" section summarizes available data to determine the baseline health status in each health impact category. To the extent possible, the section summarizes what is known about the factors that drive health in each of these categories.

For the purposes analyzing potential health impacts in this EIS, each health impact category is analyzed to determine potential linkages, or pathways, between the range of effects anticipated in other subsections of the EIS and health outcomes or factors that determine health (such as exposure to pollutants). These pathways are then analyzed in greater depth using available public health data for the region, data from comparison populations, and professional opinion.

## Limitations

- Lack of data at the village and region-level on the prevalence of some health problems, and change in the rates of these problems over the last 40 years.
- Lack of studies that have directly investigated the potential health effects related to existing oil and gas operations.
- The pathogenesis or mechanism of causation of many health problems is complex and multifactoral. Although it may be possible to identify adverse or beneficial effects of oil and gas leasing, it is often not possible to determine the precise contribution of oil and gas vs. non-oil and gas-related impacts to a given health problem.
- Small population size at the village and region level prevents the acquisition of statistically significant data for some health indices.
- Some of the data sources cited in the text report health statistics for Alaska Native residents of the region only. According to the 2000 Census, Alaska Natives make up over 70% of the NSB population. Because of statistical limitations given the small size and limited available data specific to the non-Native population, it is often not possible to make valid assessments of differential effects on Native versus non-Native populations in the region. In this EIS, statistics that refer to the "NSB" are valid for the entire North Slope population. The term "Barrow Service Unit" (BSU) refers to the Alaska Native population of the NSB region.
- The NSB and MMS negotiated NSB's role in this EIS over a number of months; consequently, work on the health subsections did not begin until July, 2008, well into the drafting of the DEIS. This did not allow time to collect data from sources that require more time for data extraction and analysis. For this reason, the NSB has clarified that some new data may be submitted between the DEIS and FEIS.

**Analysis of Potential Impacts to Public Health and Potential Mitigation Measures Proposed by the North Slope Borough to Address Health Effects.** During the planning cycle for the 2007-2012 5-year OCS Leasing Program, the NSB, AITC, and MMS held extensive discussions on the subject of public health. The MMS and NSB agreed to further consider at the lease sale stage the NSB's proposed mitigation measures related to public health impacts.

The NSB has entered an MOU with MMS for the purposes of addressing the potential public health effects of Arctic OCS leasing. The following potential new mitigation measures were developed by NSB to address potential health issues. These measures were submitted for MMS consideration. The MMS and NSB have agreed to a series of work sessions to consider these proposed measures.

## Beaufort Sea Alternative 1, No Action.

### Potential Effects Agents to Public Health.

This analysis considers effects on public health that could be brought about at the regional, community, or individual levels. Public health effects would occur in close parallel with subsistence and sociocultural

changes described in sections 4.4.1.12 and 4.4.1.13., and well as changes in environmental quality. Agents of these effects include:

(1) Vessel and aircraft noise and disturbance;
(2) Discharges and emissions
(3) Oil Spills
(4) Oil spill cleanup
(5) Seismic Surveys
(6) Habitat Loss
(7) Production Activity
(8) Habitat loss
(9) Economic, employment, and demographic change.
(10) Climate Change

## Impact Assessment Overview

The coastal communities of the Beaufort Sea—Kaktovik, Nuiqsut, Barrow and Atqasuk—and those of the Chukchi – Barrow, Wainwright, Point Hope, and Point Lay – participate in subsistence harvests of marine and terrestrial resources in the region. These resources, subsistence practices, and sociocultural systems, and public health could be affected by the effects agents discussed above.

This discussion is concerned with those communities that potentially could be affected by past and ongoing exploration, development, and production activities in the region. These include the communities of Kaktovik, Nuiqsut, Atqasuk, and Barrow. Public Health focuses on health outcomes and factors that determine these outcomes. The Public Health analysis will consider impacts to the following Health Effects Categories (HECs): (1) General Health and Well-being; (2) Psychosocial issues; (3) Accidents and Injuries; (4) Contaminant Exposure; (5) Food, Nutrition, and Physical Activity; (6) Non-communicable and Chronic Disease; (7) Cancer; (8) Infectious Diseases; (9) Maternal-Child Health; (10) Water and Sanitation; (11) Health Services Infrastructure and Capacity; and (12) Occupational/Community Health Intersection.

Public Health is one of the considerations in Environmental Justice. Whereas EJ focuses on the disproportionate public health (and other) impacts to low-income and ethnic minority populations, the Public Health subsections in this EIS address the potential health effects to the NSB community as a whole, including non-EJ populations. Because of the limitations of existing data, some data used in the health effects analysis are specific to the Alaska Native population of the NSB. These statistics will be reported as "Barrow Service Unit" (BSU), whereas statistics for the NSB population as a whole are labeled "NSB."

**Factors Affecting Public Health** An analysis of public health must account for the social, economic, and environmental influences on health status. OCS activities may directly and indirectly affect the health of populations in the region.

**Impacts to Subsistence:** As discussed in section 3.4.2, subsistence is the cornerstone of nutrition, culture, and social systems in NSB communities. A vital, productive subsistence way of life is strongly correlated with measures of overall well-being and psychosocial health in Arctic communities (Poppel et al., 2007; Hicks and Bjerregaard, 2006; Shepard and Rode, 1996). Impacts to subsistence harvest, if they were severe enough, would also impact food security, nutritional status, and the risk of nutritionally-based chronic medical problems such as high blood pressure, obesity, diabetes, and cardiovascular disease. Anyone dependent on subsistence resources could experience these effects to some degree, but they would be most prominent in Inupiat residents of the region, in whom current data suggest that subsistence is a cornerstone of general wellbeing as well as physical health.

**Changes in Environmental Quality.** Environmental quality issues account for between 10% and 20% of all deaths in the U.S. (Pruss-Ustun A, Corvalan C., 2006; Schroeder, 2007). Factors such as air quality contribute substantially to cardiovascular, pulmonary, and all-cause mortality (U.S. EPA, 2006, Ostro et al., 2006). Environmental contaminants are sometimes carcinogenic, and exposure to these factors contributes to the national burden of cancer.

The North Slope environment and communities have several unique aspects that must be considered when evaluating the influence of environmental contaminants on health. NSB communities maintain strong ties with and dependence on the natural environment and subsistence resources; residents spend considerable time on the land in subsistence activities, and consume large quantities of locally-harvested fish and game. Fish, game, marine mammals, and other subsistence foods can bioaccumulate some organic pollutants; hence exposure to locally-produced contaminants is a matter of ongoing concern in local communities. The North Slope environment is also unique in that global transport of contaminants concentrates some pollutants such as POPs and mercury from worldwide sources. Finally, Alaska Natives in the NSB region have high rates of cancer and lung disease, both of which may be associated with exposure to environmental pollutants. Each specific subtype of cancer has a variety of genetic, behavioral, and environmental risk factors. Often, a given pollutant may be a risk factor for only specific subtypes of cancer, which complicates the assessment of potential links between environmental pollution and cancer. Furthermore, other risk factors, such as high smoking rates, have been identified as risk factors for certain subsets of cancer. But, because of both the issue of increased dietary exposure because of the large amounts of wild-harvested resources and the issue of Arctic accumulation of contaminants, contaminants pose a strong and ongoing concern for NSB residents.

The main potential exposure pathways to contaminants produced by regional oil and gas activities for residents of the region would include:

1) Consumption of tainted subsistence resources: pollutants from oil and gas operations could contaminate local subsistence resources, and expose individuals to contaminants when the harvested resource is consumed.
2) Inhalation: emissions from combustion associated with exploration and production activities could be entrained in the local airshed, and inhaled by residents; subsistence hunters travelling near combustion sites, and residents nearest major emissions sources would be at greatest risk. It is important to recognize that even projects complying with NAAQS standards may produce levels of pollutants that are harmful to human health, particularly vulnerable groups such as infants, elders, and people with underlying chronic illnesses (U.S. EPA 2006; U.S. EPA Region IX 2008; U.S. EPA 2008).
3) Direct contact with skin (as could occur in the case of an oil spill).
4) Contaminated drinking water: Drinking water in the NSB is generally taken from surface water bodies, which could become contaminated through local oil and gas activities.

**Changes in Sociocultural Conditions, Demographics, and Economy:** As discussed in section 3.4.3, the field of public health has long recognized that "socio-economic status," as measured by factors such as income, employment status, and level of education, play a powerful role in health and disease. These factors – sometimes referred to as the "social determinants of health" account for at least 40% of disease rates in the U.S. (Adler and Newman, 2002; Lantz et al., 2003; Pamuk et al,. 1998). Studies in the Arctic have identified effects of socioeconomic change on social and psychological health problems (stress, alcohol and substance abuse, family violence, and suicide) (Shepard and Rode, 1996; Hicks and Bjerregaard, 2006; Bjerregaard and Young, 2004). Similarly, studies have identified physical health outcomes attributable to social and economic conditions in the Arctic, including cardiovascular disease, cancer, all-cause mortality, diabetes, and other metabolic disorders (Gessner, 2008c); Lantz et al 2006; O'Neil et al., 2003; Shaw et al., 2006; WHO 2007; Pamuk et al., 1998).

Influx of non-resident workers from outside the region can introduce new value systems and generate cultural tensions. This effect would be most prominent for Inupiat members of NSB communities. New access routes such as ice roads and permanent roads, can change the level of isolation in a community, increasing commerce and travel between urban centers and villages. Residents have reported that the ice road constructed in Nuiqsut each year has facilitated illicit drug and alcohol trafficking into a village which has banned the sale and possession of alcohol; in turn, access to alcohol and drugs increases the risk of injuries, violence, and social conflict (U.S. DOI BLM, 2004).

Influx of non-resident workers can also be a source of infectious disease transmission. Transmission of sexually transmitted diseases and bloodborne infections such as HIV between high and low prevalence groups is a commonly recognized and significant concern with resource development projects in indigenous and remote rural communities (IFC, 2007; Utzinger et al., 2005).

## Effects Definitions and Effects Levels

### Considerations in establishing effects levels for Public Health

There are several considerations in establishing effects levels for public health, including:

1) The pathogenesis of disease is complex and multifactorial:
    a. There is a long delay between exposure and overt disease for some health problems (often exceeding 10 years), making monitoring of outcomes an ineffective strategy on which to base public health interventions for these problems.
    b. There may be multiple overlapping influences and risk factors for the development of many diseases. For example, cancer may result from a combination of genetic predisposition, smoking, and exposure to carcinogens in the environment. Even exposure to a proven carcinogen at high levels might take many years to cause cancer.

2) The small numbers of people in North Slope villages make it impossible to detect statistically significant changes in the rates of some diseases, even though such changes may be occurring. For example, if the mortality rate from cancer quadruples in a village, the overall number of deaths might increase from one person in two years to two people in one year: these numbers are often too small to say with certainty that the change is not due to random variation.

Given 1) and 2), effects levels for public health account not only for health outcomes but for exposure to well-established health risk factors as well.

3) Individual adverse health outcomes can be highly significant. In small Alaska Native communities, the close interdependence between individuals, social structures, and kinship and sharing networks means that individual deaths or serious adverse health events can have far-reaching significance not only for the affected individual but for the community as well. The CEQ regulations on NEPA implementation do not distinguish between individual and population-based health effects in defining significance (40 CFR § 1508.27). Effects thresholds therefore reflect both individual and population health effects.

### Effects Levels for Public Health

1) Infrequent minor acute health problems, not requiring medical attention, with no measurable effects on community function, and no long-term consequences for community health or well-being (a *negligible* effect).

2) Community health being affected, but the effects would not disrupt normal or routine community function for more than one week, would not occur frequently, would not affect large numbers of individuals, and could be avoided with proper mitigation (a *minor* effect).
3) Adverse effects on community health occurring for brief periods of time, that do not result in or incrementally contribute to deaths or long-term disabilities and can be prevented, minimized, or reversed with proper mitigation. Effects could occur more frequently than minor events, but would not be frequent (a *moderate* effect).
4) Effects on community health would be unavoidable and would contribute to the development of disabilities, chronic health problems, or deaths. Alternatively, occurrence of minor health problems with epidemic frequency. Effective mitigation might minimize the adverse health outcomes but would not be expected to reverse or eliminate the problem (a *major* effect).

## Potential (Unmitigated) Effects

This section considers, in general, the public health effects that could occur from OCS activities without mitigation. Effects are considered for each relevant Health Effect Category (HEC) discussed in section 3.4.5.2. HECs considered include: (1) General Health and Wellbeing; (2) Psychosocial Issues; (3) Accidents and Injuries; (4) Contaminant Exposure; (5) Food, Nutrition, and Physical Activity; (6) Non-communicable and Chronic Disease; (7) Cancer; (8) Infectious Diseases; (9) Maternal-child Health; (10) Water and Sanitation; (11) Health Services Infrastructure and Capacity; and (12) Occupational-Environmental Health Intersection. For each disturbance, only the relevant HECs will be discussed.

As described in section 3.4.2, subsistence defines the core cultural values and plays a central role in the social organization, family relationships, and economy of NSB Alaska Native communities. In the North Slope region, several studies have addressed questions of the effect of living conditions on well-being. The recently completed Survey of Living Conditions in the Arctic (SLiCA) found that higher levels of income were not linearly associated with measures of well-being. In this sample, independent of income, 44% of surveyed participants who were categorized as "most active" in subsistence said they were "very satisfied" with their lives, compared with only 30% of those in the "least active" group (Poppel et al., 2007). According to available data (see section 3.4.2) wild-harvested foods also make up a considerable portion of the diet and nutrition in North Slope Alaska Native communities. Consequently, subsistence effects carry important implications for general health and well-being. The subsistence diet and way of life are the main protection for North Slope communities against chronic diseases such as cardiovascular disease and diabetes (Murphy et al 1997; Young et al 1992; Bjerregaard, Young et al 2004; Bjerregaard, Jorgensen et al 2004). The sharing networks, cooperation, and close relationships between families and communities are a measurable form of social capital, or social support. Social support is a powerful predictor of life expectancy and both psychological and physical health and well-being (Marmot and Wilkinson, 2003; Ritchie L, Gill D., 2004).

**Potential Aircraft and Vessel Disturbance Effects**. According to Section 4.4.1.12.1.1 and 4.4.1.12.1.2, effects from aircraft and vessel disturbance could result in some localized disruption of subsistence harvests for aquatic and terrestrial species, but would not be expected to make these resources unavailable to hunters.

**General Health and Well-being and Psychosocial Issues** could be affected to the extent that disturbance of traditional subsistence hunting activities contributed to overall stress or impeded participation in community subsistence activities. More difficult subsistence conditions or failed hunts could lead to stress and maladaptive coping strategies (increased alcohol or drug use, domestic violence).

**Accidents and Injuries.** If whales were displaced or made more skittish by aircraft and vessel disturbances, injuries could result from more difficult subsistence conditions. Similarly, on land, caribou

displacement or behavioral changes in response to vessel or aircraft disturbances could lead to the need to travel greater distances to harvest caribou. Snow machine accidents have been shown to occur in proportion to the miles travelled, so this could increase the risk of accidents for hunters on land (Landen et al., 1999). The extra fuel costs and wear and tear on equipment could create additional economic burdens on communities as well.

**Food, Nutrition, and Physical Activity, and Chronic Disease**. Because it is anticipated that displacement would not be severe enough to render resources unavailable to hunters (see section 4.4.1.12.1.1 and 4.4.1.12.1.2), it is possible but unlikely that vessel and aircraft disturbance effects on nutrition, diet, and related health problems would occur.

**Potential Effects from Discharges**.

**Contaminant Exposure.** Discharges permitted for OCS activities under EPA's Arctic General Permit (AKG280000, USEPA, 2006b) include drilling fluids and cuttings; deck drainage; sanitary wastes; desalination unity wastes; blowout preventer fluid; boiler blowdown; fire control system test water; non-contact cooling water; uncontaminated ballast water; bilge water; excess cement slurry; mud; cuttings and cement at seafloor; and test fluids. The most significant of these discharges for exploration activities include drilling muds and cuttings, the most potentially toxic components of which include cadmium (a known human carcinogen), mercury (a neurotoxin associated with developmental delay), barite, bentonite, lignite and lignosulphonate, and other metals including chromium, copper, nickel, lead, and zinc; wastewater discharges can contain coliform bacteria which can cause serious illness in humans.

According to EPA's NPDES analysis:

> Overall, significant impacts to human health are not expected to result from the limited discharges of drilling mud that characterize the exploratory phase in the Arctic lease sales. The hazard associated with consuming fish and shellfish contaminated with metals or petroleum hydrocarbons is expected to be low. The reasons for this assessment are: bioconcentration factors for heavy metals other than methylmercury and for mobile aromatic hydrocarbons such as benzene are too low to warrant concern about biomagnification; mercury, which is potentially the most hazardous metal, is a relatively minor constituent of drilling muds; and the areas affected by exploratory drilling discharges are too small to contribute substantially to the diet of fish or shellfish harvested by fisheries. (EPA, 2005)

However, because of the high importance of the OCS environment to the subsistence practices, health and well-being of local communities, the NSB undertook a review of the available literature used in reaching this conclusion, and notes that there are a number of assumptions and uncertainties on which it is based. First, it must be noted that metals including mercury can be found not only in drilling muds but in cuttings as well. Thus, the elevated metal concentrations sometimes seen in cuttings piles may be from a combination of cuttings, accumulation and migration from the natural sediment, from discharges of barite, from specialty chemicals in drilling muds, from the platform itself (i.e., paint chips, corrosion) and from aeolian input. The introduction of oxygen, the amount an types of specialty chemicals, and the oil content of the cuttings are all variables which influence the kinetics, chemistry, and time frame associated with the sorption (binding) and desorption (release) of metals bound up in the cuttings piles. Additionally, disruption of tailing piles may release large concentrations of metals as a result of oxidation of metal sulfide complexes. No field work has demonstrated that the metals found in cuttings piles are likely to remain in a "bound" (and therefore less bioavailable) form (Rosa C, personal communication by email, 2008.)

Another potential concern for human health associated with OCS discharges is "naturally-occurring radioactive material" (NORM), which is present in the shales from which oil and gas are extracted. During extraction, reactions can occur which result in dissolved radionuclides remaining in solution in the drilling fluids or precipitating and becoming incorporated into the solid components of drill cuttings. This process depends on water chemistry, temperature, and pressure. Chronic exposure to radiation may result in mortality, mutagenesis, or decreased fertility or sterility for exposed organisms (Holdway, 2002).

Acute effects of OCS discharges reported in the literature include (1) altered benthic communities; (2) decreased abundance of barnacles within mixing zones; (3) species mortality in discharge zone. Chronic effects that have been observed include (1) altered benthic community species by composition (plant and animal); (2) altered behavior, growth, and decreased fecundity of laboratory species exposed to cuttings; (3) notable health problems among benthic species, including decreased immune function, altered biochemical functioning, and increased mortality (Dow et al., 1990; Holdway, 2002; March, 2003; Breuer et al., 2004). The particular effects of the variables discussed above on the marine environment of the Beaufort and Chukchi seas have not been investigated. The NSB concludes that:

> All of these effects may take place where human food is harvested. At this time, the total number of exploratory wells is unknown. The waste from a small number of wells might not produce deleterious effects, but over time the waste from hundreds of wells would have serious adverse effects on this important subsistence hunting and marine mammal feeding ground. (Rosa, 2008, personal communication).

Community concern over potential contamination, coupled with acknowledged data gaps (such as the lack of baseline data regarding current levels of contaminants produced by local oil and gas operations in subsistence species (U.S. DOI BLM, 2007), and the absence of any quantitative nutritional data delineating the amount of subsistence foods consumed) create a considerable amount of uncertainty about the validity of EPA's conclusions within the community, and may undermine community confidence in the safety and health of OCS subsistence resources. Whalers are meticulous while on the ice during spring whaling in their efforts to prevent even miniscule amounts of contaminants from contacting whales (Lohman, 2007, personal communication). Another concern voiced by some whalers is that whales will alter their migration routes in order to avoid even small amounts of contaminants. Fears about contamination are well-documented causes for decreased participation in subsistence activities and decreased consumption of subsistence foods (Ballew et al., 2004; Poppel et al., 2007). Decreased consumption of subsistence foods would constitute an adverse effect on general health and wellbeing, food, nutrition, and physical activity, and would increase the risk of chronic diseases such diabetes, obesity, and hypercholesterolemia. Any activity that creates doubt and challenges communities' confidence in and relationship to the natural resources on which they depend would be expected to lead to increased anxiety, stress, and exacerbate rates of social and psychological problems. It is very important to note that to date, the available data have suggested that the subsistence food supply for NSB communities is safe, in some cases with lower levels of contaminants than other Arctic nations (AMAP, 2003; ADHSS, 2004a; ADHSS, 2004b;

The NSB is undertaking a more in depth review of international best practices for managing OCS discharges, and anticipates offering further information between the DEIS and FEIS.

**General Health and Wellbeing; Psychosocial Issues.** Fears that contaminants from OCS activities may impact subsistence resources, coupled with gaps in the data available to assess the risks posed by future OCS activities, could be a substantial source of stress in impacted communities. Uncertainty regarding the safety and future productivity and sustainability of subsistence resources is already a significant source of stress in NSB communities.

**Food, Nutrition, and Physical Activity; Chronic Disease.** Community concern over potential contamination, coupled with acknowledged data gaps (such as the lack of baseline data regarding current levels of contaminants produced by local oil and gas operations in subsistence species (U.S. DOI BLM, 2007), and the absence of any quantitative nutritional data delineating the amount of subsistence foods consumed), however, creates a certain amount of uncertainty in the assessment of the risks posed by OCS discharges. Whalers are meticulous while on the ice during spring whaling in their efforts to prevent even miniscule amounts of contaminants from contacting whales (Lohman, 2007, personal communication). Fears about contamination are well-documented causes for decreased participation in subsistence activities and decreased consumption of subsistence foods (Ballew et al., 2004; Poppel et al., 2007). In this case, the recognized data gaps regarding the subsistence consumption contaminant exposure pathway could contribute to these fears and exacerbate the problem, leading to decreased consumption of available subsistence resources. Lack of confidence in the food supply would increase food insecurity, and potentially lead to increased reliance on market foods. Decreased consumption of subsistence foods and an increased reliance on market foods would place communities at substantially higher risk for problems such as diabetes, obesity, and hypercholesterolemia.

**Potential Effects from Oil Spills.**

**Large Oil Spills.** Large oil spills could cause effects on public health through contact with contaminants -- which could occur mainly through inhalation, skin contact, or intake of contaminated subsistence foods; through reduced availability or acceptability of subsistence resources; periodic interference with subsistence-harvest patterns from oil spills and oil-spill cleanup, and stress due to fears of the long-term implications of a spill and the disruptions it would cause. Traditional practices for harvesting, sharing, and processing subsistence resources could be seriously curtailed in the short term, if there are concerns over the tainting of bowhead whales and other marine mammals from an oil spill, and overall effects from these sources could be expected to displace ongoing sociocultural systems (USDOI, MMS, 2007d).

**General Health and Wellbeing and Psychosocial Issues.** Impacts on general health and wellbeing from a large oil spill would occur through interruptions of subsistence harvest, sharing networks, and community organization. The relationship between subsistence and general health and wellbeing is described in section 3.4.3 and 3.4.5.2.1. Experience with the EVOS demonstrated long-term disruptions in community functioning, sharing networks, and social capital, with implications for wellbeing and indicators of general health. (Ritchie and Gill, 2004; Marmot and Wilkinson, 2004). Studies of the EVOS also found a substantially higher rate of Post-traumatic stress disorder, generalized anxiety disorder, and depressive symptoms in community members impacted by the EVOS (Palinkas et al. 1993; Palinkas et al. 2004). The recently completed Survey of Living Conditions in the Arctic (SLiCA) found that higher levels of income were not linearly associated with measures of well-being. In this sample, independent of income, 44% of surveyed participants who were categorized as “most active” in subsistence said they were “very satisfied” with their lives, compared with only 30% of those in the “least active” group (Poppel et al. 2007). Actual or perceived contamination of subsistence resources after a large oil spill would thus create higher levels of stress and would be likely to cause and exacerbate social and psychological disorders as well. Even in the absence of an actual spill, the risk of a large oil spill is a matter of intense and ongoing concern to NSB coastal communities in relation to the recent increased interest in OCS development, as described in section 4.4.1.12.4.5.

**Accidents and Injuries.** Unintentional injury is the second leading cause of death on the North Slope (and the 3rd leading cause of death for Alaska Natives statewide), with mortality rates over 3.5 times higher than the rate for U.S. whites. Unintentional injury rates tend to parallel psychosocial issues to the extent that over 38% of unintentional injury hospitalizations statewide involve alcohol (ANTHC 2008). Unintentional injury rates also reflect the very real dangers of a subsistence way of life in Arctic Alaska.

One study demonstrated that injury rates increase in proportion to miles travelled by snow machine (Landen et al. 1999). In the case of a large oil spill the rate of accidents and injuries could increase if people resort to maladaptive coping strategies such as alcohol or substance abuse, or if hunters find it necessary to travel longer distances to contact resources that have not been impacted by the spill.

**Contaminant Exposure.** Exposure to contaminants could occur through several pathways in a large oil spill. Direct contact with crude oil through dermal contact or inhalation could occur for people in the path of the spill. Inhalation of volatile fractions entrained in the airshed could occur downwind of the spill. Similarly, if in-situ burning were utilized, inhalation of the combustion products could occur as well. Finally, consumption of contaminated subsistence foods could also expose people to unsafe levels of constituents of crude oil.

Crude oil is a complex mixture of hydrocarbons, and the potential health effects depend to some extent on the degree of exposure, route of exposure, chemical composition of the spilled material, and timing of the exposure.

Exposure to crude oil and its components is associated with a wide range of adverse health effects. Acute exposure by inhalation can cause a range of non-specific symptoms including sore throat, burning eyes, vomiting, headache, and general malaise (Lyons et al., 1999; Park and Holiday, 1999). Skin exposure is another route. In acute exposures, rashes have commonly been reported (Gorman et al 1991). Exposure to hydrogen sulfide gas in "sour" crude oil can be lethal. Acute exposure to other constituents of crude oil, such as PAH and benzene, is associated with central nervous system problems, but these appear to resolve fairly quickly after cessation of exposure (Park and Holiday, 1999).

Chronic exposure to crude oil and its constituents could occur through inhalation or consumption of tainted subsistence foods, and is associated with a range of health problems. Benzene is a class I human carcinogen, associated primarily with leukemia (Park and Holiday, 1999; ATSDR 1999a). PAH are a diverse group of compounds found in crude oil. A number of PAH are felt to be likely carcinogens and neurotoxins (ATSDR 1995). Based on limited experimental data, ATSDR determined that benzene is not likely to bioaccumulate in aquatic organisms. It can bioaccumulate in plants through uptake in leaves (ATSDR 2007). Some PAH can bioaccumulate in subsistence species, and humans could be exposed through consumption of tainted subsistence foods (ATSDR, 1995).

Limited epidemiologic data are available to evaluate the health risks of chronic exposure to crude oil constituents in the environment. One set of peer-reviewed studies found an elevated risk of cancer and miscarriages associated with chronic exposure to TPH (San Sebastian et al. 2001; San Sebastian et al. 2002; Hurtig and San Sebastian, 2002.)

**Food, Nutrition, and Physical Activity, Chronic Disease.** Effects on food, nutrition, and physical activity and on the risk of chronic diseases such as diabetes, high blood pressure, and cardiovascular disease would relate primarily to impacts on subsistence resources. Contamination of subsistence resources could reduce their availability or suitability for consumption; concerns about potential safety would likely influence harvest and consumption patterns to some extent independent of evidence of food safety. Effects on nutrition, food security, and chronic disease would be proportional to the severity of the spill and the effects on subsistence harvests. Cancer risks could increase because of exposure to contaminants as described above.

**Maternal-Child Health.** Some components of crude oil are known or suspected mutagens, and if pregnant women were exposed in high enough quantities, birth defects could occur (ATSDR, 1995).

Limited epidemiological data have suggested an association between chronic exposure to TPH and miscarriages (San Sebastian et al., 2002).

**Health Services Infrastructure and Capacity and Occupational/Community Health Interface.** In the case of a large oil spill contacting workers or a community, local infrastructure and services as well as occupational health services could be strained. A study of health visits after a large oil spill found that there were numerous clinic visits for minor health problems (Lyons et al., 1999). The State of Alaska and the Alaska Native Tribal Health Consortium have developed an ongoing emergency preparedness partnership which could offer a framework through which occupational and community health service coordination.

**Potential Effects from Oil Spill Cleanup**

Deflection of resources, resulting from the combination of a large oil spill and spill-response activities, would persist beyond the timeframe of a single season, perhaps lasting several years. The result would be a major effect on subsistence harvests and subsistence users, who would suffer impacts on their nutritional and cultural well-being. The sudden employment increase could have sudden and substantial effects, including inflation and displacement of Native residents from their normal subsistence-harvest activities by employing them as spill workers. Cleanup employment of local Inupiat also could alter normal subsistence practices and put stresses on local village infrastructures by drawing local workers away from village service jobs. On the other hand, employment and income are generally associated with positive health outcomes. Cleanup is unlikely to add population to the communities, because administrators and workers would live in separate enclaves (USDOI, MMS, 2003a, 2007d). Increased flux of non-resident personnel through communities, on the other hand, would be highly likely, and could have impacts on social interactions and commerce-related economy and inflation.

**General Health and Wellbeing and Psychosocial Issues.** Effects would be similar to those described for large oil spills. Impacts on general health and wellbeing from a large oil spill would occur through interruptions of subsistence harvest and sharing networks, through sudden shifts in employment status, and through a rapid influx of oil spill cleanup personnel. Studies of the EVOS also found a substantially higher rate of post-traumatic stress disorder, generalized anxiety disorder, and depressive symptoms in community members impacted by the EVOS (Palinkas et al., 1993; Palinkas et al., 2004).

**Accidents and Injuries.** To the extent that cleanup activities exacerbated disruptions of subsistence activities, they could lead to higher rates of injuries as well, through the mechanisms described for large oil spills. On the other hand, successful cleanup efforts would be an essential step toward eventual restoration of subsistence habitat and practices.

**Infectious Diseases.** The rapid influx of non-resident cleanup personnel presents a risk of infectious disease transmission between the NSB residents and people entering the region from outside the region. All NSB villages are isolated – accessible mainly by air. There are two considerations related to the risks associated with infectious disease transmission: (1) the mixing of high and low prevalence groups, and (2) vulnerable populations.

The prevalence of HIV in the Northern Region of Alaska appears to be substantially lower than prevalence in the general U.S. population (ADHSS, Section of Epidemiology, 2002, 2007). Risk factors for bloodborne infections include IV drug use and high-risk sexual behavior. HIV transmission rates depend on rates of IV drug use, number of sexual partners, and use of appropriate barrier contraceptives. The prevalence of Chlamydia in the NSB is higher than the U.S. general population, whereas gonorrhea rates are lower. Natural resource development projects such as OCS activities that involving an influx of non-resident workers have the potential to change incidence and prevalence patterns of bloodborne and

sexually transmitted infections through the mixing of high and low prevalence populations (IFC 2007; Utzinger, Wyss et al,. 2005).

Respiratory infections can be minor and self-limited (upper respiratory tract infections), or more severe requiring medical attention or hospitalization. However, vulnerable populations – particularly those with chronic lung disease – are at increased risk of severe complications from contracting even minor respiratory infections. Chronic lung disease is highly prevalent in the NSB. Overcrowded housing conditions and a large influx of non-resident workers could increase the transmission of respiratory illnesses, with adverse effects particularly for those with underlying chronic lung disease.

**Food, Nutrition, and Physical Activity.** Effects on food, nutrition, and physical activity and on the risk of chronic diseases such as diabetes, high blood pressure, and cardiovascular disease would occur in proportion to the severity of subsistence-related effects.

**Health Services Infrastructure and Capacity and Occupational/Community Health Interface.** A large influx of non-resident cleanup personnel could strain existing community and occupational health services. The State of Alaska and the Alaska Native Tribal Health Consortium have developed an ongoing emergency preparedness partnership which could offer a framework through which occupational and community health service coordination.

**Potential Effects of Airborne Emissions.**

**Contaminant Exposure; Chronic disease.** Airborne emissions from oil and gas activities include the EPA "criteria pollutants" (NOx, $SO_2$ $PM_{10}$, $PM_{2.5}$, lead, and CO, and, indirectly, ozone, through photochemical reactions with NOx), which have been associated with an array of health effects, the most common and significant of which include causing and exacerbating respiratory illnesses such as asthma; increased risk of cardiac arrhythmias; exacerbated atherosclerotic coronary artery disease; and excess overall mortality rates among vulnerable groups. According to the EPA, $PM_{2.5}$ in particular is associated with "increased respiratory symptoms, such as irritation of the airways, coughing, or difficulty breathing, for example; decreased lung function; aggravated asthma; development of chronic bronchitis; irregular heartbeat; nonfatal heart attacks; and premature death in people with heart or lung disease" (EPA 2005). Airborne emissions from OCS activities could contribute incrementally to the risk of these health problems. The possible contribution of emissions from oil and gas facilities must be viewed in the broader context of air quality on the North Slope. Other potentially important sources of exposure to air pollutants include road dust, combustion of fuels (for example, auto exhaust, power plant emissions), indoor air pollution, and burning of refuse (U.S. DOI BLM, 2007). Compelling data have also linked social and economic factors to respiratory health outcomes. For example, in Alaska a recent study demonstrated that the average educational status in a community was a strong predictor of asthma outcomes (Gessner, 2008). Similarly, data have shown that poverty predicts adverse health outcomes from exposure to pollution (O'Neil et al. 2008).

According to ADEC,

> "Transport and deposition of pollution downstream of the North Slope facilities may be having a noticeable effect on the environment of the NPR-A. Currently, no data has been collected to document if the substantial amount of pollution emitted on the North Slope, although not in violation of air standards, may be having a significant cumulative effect on this area" (ADEC, 2007).

ADEC further notes that:

> Air monitoring data is limited on the North Slope, especially in the NPR-A. Existing air monitoring data is collected by the oil companies as part of their air permit requirements and monitoring is not performed at locations several hundred miles downwind of the facilities. While

> North Slope air quality data has not shown violations of the National Ambient Air Quality Standards (NAAQS) near the facilities, concerns exist about the ability of older air quality models to predict deposition given the North Slope's strong atmospheric stability, complex high latitude atmospheric chemistry, the secondary formation of pollutants trapped in mid to long distance transport, and deposition of air pollutants which can accumulate in the soil and vegetation. (ADEC, 2007).

Thus, although air quality modeling of typical OCS activities in the Beaufort and Chukchi Seas has demonstrated that with appropriate emission control technologies, criteria pollutant concentrations would be below the PSD incremental limits and the NAAQS, there are acknowledged uncertainties in this conclusion. Furthermore, while NAAQS standards are promulgated to protect health, public health data demonstrate that these standards are only partially protective, because there are still demonstrated health effects at levels below NAAQS standards.

HAP emitted by OCS activities can have adverse impacts on public health. Among the HAP most commonly associated with oil and gas activities include benzene, toluene, ethylbenzene, and xylene (BTEX), and PAH (a large category of chemically related pollutants produced by combustion of hydrocarbons.) Some of these compounds are known or suspected human carcinogens. PAH have been also shown to exacerbate asthma and may be associated with the development of asthma as well (Miller et al. 2004). BTEX generally volatilize and are dispersed in the atmosphere. Studies have shown, however, that entrainment and wind conditions can lead to unhealthy concentrations of BTEX in communities adjacent to emissions sources (Municipality of Anchorage, 2005). Benzene has a moderate potential to bioaccumulate in plants, and a low potential to bioaccumulate in marine animals, according to a toxicological profile by ATSDR (ATSDR 2007); the accumulation in mammals that browse on contaminated vegetation has not been studied. PAH have a more complex fate. Studies have shown that some airborne PAH from OCS activities are also deposited in the marine environment (Hawbolt and Adams, 2005; Hawbolt et al. 2006).

Table J-76 gives an inventory of permitted emissions on the North Slope. These figures do not include mobile sources such as drill rigs and portable flares, as well as many exploratory operations; HAP are also not estimated by many facilities, so these numbers may underestimate actual emissions.

**Potential Seismic Survey Effects.** The greatest potential disruption from seismic-survey activities on the subsistence whale hunt would be expected during fall whaling in Kaktovik, Nuiqsut, and Barrow, if multiple seismic-survey operations deflect whales away from traditional hunting areas. Barrow's fall hunt would be particularly vulnerable. Noise effects from multiple seismic surveys to the west in the Chukchi Sea and to the east in the Beaufort Sea could cause migrating whales to deflect farther out to sea, forcing whalers to travel farther; thus, increasing the effort and danger of the hunt and increasing the likelihood of whale meat spoilage, as the whales would have to be towed from greater distances.

**General Health & Wellbeing; Psychosocial & Gender Issues.** As described in section 3.4.2, subsistence defines the core cultural values and plays a central role in the social organization, family relationships, and economy of NSB Alaska Native communities; section 3.4.7 describes the role of subsistence in general health and wellbeing and psychosocial issues. The recently completed Survey of Living Conditions in the Arctic (SLiCA) found that higher levels of income were not linearly associated with measures of well-being. In this sample, independent of income, 44% of surveyed participants who were categorized as "most active" in subsistence said they were "very satisfied" with their lives, compared with only 30% of those in the "least active" group (Poppel et al., 2007). Social support has a direct effect on all-cause mortality (Marmot and Wilkinson, 2004). Social interconnectedness and stability in core cultural and social institutions constitute the core of community health and well-being in Inuit communities, with numerous studies showing a connection between measures of cultural continuity and mental health (see e.g. Chandler and Lalonde, 1998; Bjerregaard P., 2001; Curtis et al., 2005). According

to available data (see section 3.4.2) wild-harvested foods also make up a considerable portion of the diet and nutrition in North Slope Alaska Native communities, and are protective against many of the most common causes of chronic illness and mortality in the U.S. population.

Perceived and actual threat to subsistence constitute a significant source of ongoing stress and tension in North Slope communities (see, e.g., section 4.4.1.12). As stated by a Nuiqsut resident and community health aide:

> When our people can feed themselves, they're very happy. They don't care if they don't have a job as long as they're providing for their families, as long as they have hope in their mind of the possibility to provide for their families. You take away that hope, and you're going to have many, many people that we lose to the social ills. (Ahtuangaruak, in U.S. DOI MMS 2001.)

Any disruption of subsistence harvests by seismic activity could disrupt the central Inupiat cultural value (subsistence), the foundation of the North Slope nutritional system, and sharing networks, and would thereby adversely affect indicators of general health and wellbeing and could adversely impact the rates of psychosocial problems such as family violence, drug and alcohol problems, depression, anxiety, and suicide.

**Accidents and Injuries.** Unintentional injury is the second leading cause of death on the North Slope (and the 3rd leading cause of death for Alaska Natives statewide), with mortality rates over 3.5 times higher than the rate for U.S. whites. Unintentional injury rates tend to parallel psychosocial issues to the extent that over 38% of unintentional injury hospitalizations statewide involve alcohol (ANTHC, 2008).

Displacement of whales would increase the distances that whalers must travel for successful harvest and potentially involve travel into rougher waters, with a proportional increase in the risk of accidents and injuries. The longer distances and time required would increase exposure of whaling crews to weather changes, which would compound the risk. Whalers have reported that whales disturbed by seismic activity can become less predictable and more dangerous to those who hunt them. Hence, whalers could face an increased risk of serious injury or death if whales are displaced from their normal migration patterns by seismic activity. If stress over harvest failures related to seismic activity led to maladaptive coping such as alcohol abuse, this could compound the risk of increased injury rates related to seismic activity.

**Food, Nutrition, and Physical Activity; Chronic Disease.** Marine mammals are an essential part of the diet in the affected communities. Traditional foods provide a range of micronutrients essential to health including vitamins A, D, and E (Bersamin A, Zidenberg-Cherr S, Stern JS, Luick BR 2007), and iron (Nobmann ED, et. al 2005). This diet provides very high levels of omega-3 (n-3) fatty acids, anti-inflammatory substances found in high quantities in marine mammals and cold-water fish (Murphy NJ, et. al 1995; Ebbesson et al, 2007). Replacement of subsistence foods with store-bought foods in Alaska Native communities increases the risk of "metabolic disorders" such as hypertension, diabetes, and high cholesterol and the common complications of these disorders, such as cardiovascular disease and strokes (Murphy et al., 1997; Young et al., 1992; Bjerregaard, Young et al., 2004; Bjerregaard, Jorgensen et al., 2004).

Sharing networks might compensate to some extent for an isolated harvest failure related to seismic activity, but if losses were substantial, occurred in more than one village, or recurred, the nutritional system of Kaktovik, Nuiqsut, Barrow, and Atqasuk (which is dependent on sharing from other villages) would be adversely affected. The correlation between harvest amounts and nutritional intake has not been adequately assessed, although studies demonstrate that subsistence is a vitally important part of food security, nutrition, and dietary intake in the NSB (NSB 2005; Poppel et al., 2007). ADF&G estimated that "replacement" costs (a term to which many residents object because it is not possible to buy true

replacement foods) for subsistence foods harvested in Arctic Alaska ranged between $35 million and $56 million in 2000 (ADF&G, 2000).

Food insecurity would thus likely increase as a result of harvest failures, and the severity of this problem would be proportional to the number and extent of failures and to the effects on extended sharing networks that reach outside the affected community. Store-bought foods would not be expected to provide adequate replacement micronutrients, and micronutrient deficiencies and anemia could result. If it became necessary to replace subsistence calories with store-bought foods, this would incrementally increase the risk of metabolic syndrome disorders including diabetes, hyperlipidemia, and high blood pressure, with the severity of this problem correlating with the severity and frequency of impacts to subsistence.

### Potential Effects from Habitat Loss

Pads, gravel quarries, pipelines, pump stations, and gravel roads that cross much of the Central Arctic caribou herd's calving range actually have destroyed only about 3-4% of the tundra grazing habitat for caribou. Walker et al. (1987) considered these to be major landscape impacts and recommended that the implications to wetland values, wildlife corridors, and caribou calving grounds be addressed. Alterations from offshore production platform-island construction, trench dredging, and pipeline burial would affect some benthic organisms and some fish species within 1 km for <1 year or season. These activities also temporarily would affect the availability of some local food sources for these species up to 1-3 km (0.62-1.9 mi) distance during island construction, but these activities would not be expected to affect food availability for seals over the long term.

The public health effects of habitat loss would be expected to mirror impacts to subsistence resources: the health implications of such impacts are described above in detail in section 4.4.1.3.17.5.6. An additional concern would be stress and dysphoria caused by the proliferation of industrial infrastructure within view of communities, subsistence camps, and hunting routes. As noted by the NSB health director, Inupiat people are accustomed to am expansive, predominantly flat natural landscape with little interruption by vertical elements such as mountains, buildings (other than within villages), or other infrastructure (Habeich 2007, personal communication). The visuospacial changes created by pipelines, pads, rigs, and facilities associated with oil and gas development may have significant implications for people's relationship with the natural environment, sense of well-being, and psychological health.

### Potential Effects of Economic, Employment, and Demographic change

**General Health and Well-being.** As described in section 3.4.3 and 3.4.5, Socioeconomic status – as measured by income, education, or employment variables, is powerfully associated with both population health indicators – such as life expectancy and overall mortality rates – and rates of individual diseases such as cancer and cardiovascular disease (Adler and Newman, 2002; Pamuk et al. 1998). Some studies of Arctic indigenous communities including the NSB population suggest that the relationship is more complex. Factors related to socio-economic change – such as cultural disintegration, loss of indigenous language, and the growing contribution of modern convenience foods to the diet in rural villages, for example, have contributed to health problems (WHO 2007; Curtis T et al., 2005; Poppel et al., 2007). On the other hand, income from employment and other oil revenues supports fuel and equipment for subsistence activities and thus supports general health and well-being (CIT). Economic decline, job loss, and poverty are strongly associated with increased all-cause mortality and the development of a number of specific health problems (Jones L, 1991).

The economic effects of OCS development on health are complex. The contribution of Beaufort lease sales to overall NSB economy and employment would be relatively small (see section 4.4.2.11), and would thus likely present only an incremental contribution to the overall relationship between economy

and health in the NSB, although as revenues from onshore development decline in coming decades, OCS development could represent an increasingly important revenue source. On the other hand, it is important to recognize that communities sometimes experience "hidden" costs associated with nearby oil and gas operations. For example, in California, 3 counties near offshore development estimated that OCS activities were creating increased costs through demand on services and infrastructure (Powers M. et al., 2000). Another recent study documented increase crime rates, DUIs, and EMS calls in proximity to active onshore gas development (ERG, 2007).

**Psychosocial Issues; Accidents and Injuries.** Economic depression and unemployment are risk factors for social and psychological problems (Murali, Ovebode, 2004; Adelson N., 2005). The rapid influx of non-resident personnel to or through a community could lead to increased social and psychological problems. Few studies have addressed the psychosocial impacts of oil and gas "booms" on local communities. One recent study found a trend toward increased arrest rates and increased S calls proportional to the number of active gas wells within a certain radius of a community (Ecosystem Resource Group, 2007). Experiences from Arctic subsistence communities located near industrial enclaves suggest a number of potential concerns, including: (1) Local business agreements and sudden inflow of cash and employment opportunity can disrupt social cohesion and create economic disparity, which are associated with adverse health outcomes (Marmot and Wilkinson, 2003). In Nuiqsut, for example, a local researcher noted anecdotally that an increase in village corporation revenues associated with the Alpine project led to income disparities within the community which contributed to community tension, and also material differences in community members' ability to afford equipment for subsistence activity (Galginaitis, personal communication, 2007). (2) The flow of non-resident workers through communities can overstress local police staffing, and therefore compromise the efficacy of local drug and alcohol laws. Some reports from Nuiqsut suggest that ice road that now connects the community with Alpine and the Alaska road system in the winter has been used for illicit drug and alcohol importation (CIT). Similar problems have been reported in other Arctic indigenous communities near industrial enclaves (Gibson and Klinck, 2005; North Slave Metis Association, 2002). (3) The flow of non-resident workers through a community also creates the risk of infectious disease transmission between the host community and people from outside the area; this is most concerning for diseases which are relatively less common in the host community, such as HIV.

Overall, OCS activities would make a modest positive contribution to the NSB economy, and could thus help to prevent or forestall economic declines as onshore production wanes. To the extent that accidents and injuries correlate with psychosocial health problems, the economic inputs from OCS activities could make an incremental positive contribution as well. If, however, local residents were to become substantially integrated into oil field operations and the local communities were to become dependent on revenues associated with their operation, the community would face a period of sharp adjustment as fields were abandoned.

**Food, Nutrition, and Physical Activity; Chronic Disease.** As described in preceding sections on Food, Nutrition, Physical Activity, and Chronic Disease, subsistence constitutes a mainstay of the nutritional system of NSB communities, and the primary protection against food insecurity, nutritional deficiencies and metabolic disorders such as diabetes, obesity, high blood pressure, and cardiovascular disease. Income from OCS activities supports subsistence activities. On the other hand, the transition from subsistence to a cash economy has been associated in an increased reliance on market foods. Furthermore, there are data that employment in industrial settings for Arctic subsistence peoples may interfere with subsistence hunting. One study, for example, noted that indigenous miners working 2 weeks shifts at a remote Canadian mine participated less frequently in hunting activities because of the time demands of employment (Gibson and Kinck, 2005).

Compelling data have also linked social and economic factors to respiratory health outcomes. For example, in Alaska a recent study demonstrated that the average educational status in a community was a strong predictor of asthma outcomes (Gessner, 2008). Similarly, data have shown that poverty predicts adverse health outcomes from exposure to pollution (O'Neil et al. 2008).

**Infectious Disease.** There are several infectious disease considerations for OCS development. The influx of non-resident workers to NSB communities creates the possibility of transmission of pathogens between the NSB residents and people entering the region from outside the region. All NSB villages are isolated – accessible mainly by air. There are two considerations related to the risks associated with infectious disease transmission: (1) the mixing of high and low prevalence groups, and (2) vulnerable populations.

The prevalence of HIV in the Northern Region of Alaska appears to be substantially lower than prevalence in the general U.S. population (ADHSS, Section of Epidemiology 2002, 2007). Risk factors for bloodborne infections include IV drug use and high-risk sexual behavior. HIV transmission rates depend on rates of IV drug use, number of sexual partners, and use of appropriate barrier contraceptives. The prevalence of Chlamydia in the NSB is higher than the U.S. general population, whereas gonorrhea rates are lower. Natural resource development projects such as OCS activities that involving an influx of non-resident workers have the potential to change incidence and prevalence patterns of bloodborne and sexually transmitted infections through the mixing of high and low prevalence populations (IFC 2007; Utzinger et al., 2005).

Respiratory infections can be minor and self-limited (upper respiratory tract infections), or more severe requiring medical attention or hospitalization. However, vulnerable populations – particularly those with chronic lung disease – are at increased risk of severe complications from contracting even minor respiratory infections. Chronic lung disease is highly prevalent in the NSB. OCS activities in which substantial contact between residents and non-resident workers is anticipated could create conditions in which minor respiratory infections are transmitted between workers and the community, with more serious consequences for community members with baseline pulmonary problems.

**Water and Sanitation.** The NSB budget currently supports water and sanitation infrastructure for coastal villages in the region. OCS revenues would contribute incrementally to the overall revenues available to the NSB for these services.

**Health Services.** The NSB provides a number of health services, delineated in section 3.4.7. OCS revenues would contribute incrementally to the overall revenues available to the NSB for these services.

**Occupational/Community Health Interface.** Because some influx of non-resident workers is anticipated, there are a number of issues pertaining to OCS development and the interface between industry occupational health policies and community health that can affect public health. These include:

1) The risk of infectious and sexually-transmitted disease transmission between employees and residents. Employee health screening protocols may have an impact on rates of transmission between the community and workers. Similarly, immunization requirements for workers would be an important consideration to ensure that preventable diseases are not brought into the region.
2) Illicit trafficking of drugs and alcohol has been reported to occur by residents. Policies of screening for substance abuse disorders, and enforcement policies for drug and alcohol possession by employees are relevant considerations when an influx of non-resident workers is anticipated.
3) Finally, cultural orientations can be an important means to minimize cultural strain from conflicting values and social conventions when communities interact with non-resident workers.

## Potential Effects from Production Activity

This section reviews the potential public health effects associated with production activity, which includes (1) vessel and aircraft presence and noise; (2) airgun noise associated with seismic surveys; (3) facility placement, operation, and maintenance in offshore areas; (4) pipeline trenching and construction; (5) off- and onshore pipeline placement, maintenance, and operation; (6) pipeline maintenance roads; (7) other facilities (such as onshore landfalls and processing facilities) located in subsistence-resource habitat or key subsistence-harvest areas.

NSB communities are remote rural communities accessible mainly by air from population centers in Alaska. The need to install up to 4-13 production platforms, drill 160-400 production wells, construct 90-550 mi of offshore pipeline, up to 500 mi of onshore pipeline, and construct 3 pipeline landfalls and 2 new shorebases in the region could increase the areas and times where subsistence resources and activities are restricted. This would increase the possibility for significant harvest disruption. This would be further exacerbated if construction and production activities were concentrated in critical subsistence-use areas rather than dispersed. The most difficult potential onshore pipeline effects to mitigate would be those related to pipeline servicing and access. If a service road is constructed for this purpose, it would greatly increase impacts to caribou movement and access to subsistence resources on the western part of the North Slope. This effect would be greater if such a road were eventually opened to public access, on the model of the Dalton Highway.

**General Health and Well-being; Psychosocial/Gender Issues.** The potential disruption of subsistence by production activity (section 4.4.1.12.1.8) could affect general health and well-being. Section 3.4.2 describes the role of subsistence in general health and wellbeing and psychosocial issues. The recently completed Survey of Living Conditions in the Arctic (SLiCA) found that higher levels of income were not linearly associated with measures of well-being. In this sample, independent of income, 44% of surveyed participants who were categorized as “most active” in subsistence said they were “very satisfied” with their lives, compared with only 30% of those in the “least active” group (Poppel et al., 2007). Social support has a direct effect on all-cause mortality (Marmot and Wilkinson, 2004). Social interconnectedness and stability in core cultural and social institutions constitute the core of community health and well-being in Inuit communities, with numerous studies showing a connection between measures of cultural continuity and mental health (see e.g. Chandler and Lalonde, 1998; Bjerregaard P., 2001; Curtis et. al., 2005). According to available data (see section 3.4.7) wild-harvested foods also make up a considerable portion of the diet and nutrition in North Slope Alaska Native communities, and are protective against many of the most common causes of chronic illness and mortality in the U.S. population. The life and social structure of villages could be substantially impacted by increased interactions with non-resident workers because of new roads and shorebases in the region. Local economies could also experience considerable change. In the case of Nuiqsut, for example, the village corporation has business agreements with CPAI, and also operates a work camp in the town. Local business opportunities, inflation of prices for goods, services, and housing, and employment changes could all affect family and village-level economics. Income disparity could increase if some residents benefited or were more adversely impacted than others from these changes. Income disparity exerts a powerful adverse impact on general health and well-being and psychological health (Marmot and Wilkinson, 2004). On the other hand, income and employment from OCS activities, while not predicted to become a dominant force in the local economy, could incrementally contribute to stabilizing village economies and improve health and well-being through providing funds that support subsistence activities and employment opportunities for local residents. Some studies of Arctic indigenous communities including the NSB population suggest that the relationship between income and employment and well-being is more complex. Factors related to socio-economic change – such as cultural disintegration, loss of indigenous language, and the growing contribution of modern convenience foods to the diet in rural villages, for example, have contributed to health problems (WHO 2007; Curtis T et al. 2005; Poppel et al. 2007). At the conclusion of abandonment and rehabilitation activities, economic decline in the NSB and

villages may become a serious problem in the NSB. Economic decline and unemployment are strongly associated with increased all-cause mortality and the development of a number of specific health problems (Jones L, 1991).

New roads and access routes could be associated with new social impacts for previously isolated villages. Roads would make it easier for individuals to bring illegal drugs or alcohol into local communities, thereby compromising the efficacy of local prohibition ordinances and straining local law enforcement capacity. The construction of 2 new shorebases in the region, depending on whether they are sited near or adjoining villages or subsistence camps, could lead to increased presence of non-resident workers in and near villages, and could lead to increased social strain and psychological and social problems, such as alcohol and drug abuse, anxiety and depression, violence, and suicide.

**Accidents and Injuries.** Unintentional injury rates tend to parallel psychosocial issues to the extent that over 38% of unintentional injury hospitalizations statewide involve alcohol (ANTHC 2008). Unintentional injury rates also reflect the very real dangers of a subsistence way of life in Arctic Alaska. One study demonstrated that injury rates increase in proportion to miles travelled by snow machine (Landen et al. 1999). Production activities could exacerbate accident and injury rates if people resort to maladaptive coping strategies such as alcohol or substance abuse, or if hunters find it necessary to travel longer distances to contact resources that have not been impacted by the spill.

**Contaminant Exposure.** Effects on contaminant exposure are discussed in sections 4.4.1.15.2.2, 4.4.1.15.2.3, and 4.4.1.15.2.5.

**Food, Nutrition, and Physical Activity; Non-communicable and Chronic Disease.** Adverse effects on subsistence harvest discussed in section 4.4.1.15.1.2.1 could result in increased food insecurity, nutritional deficiencies, and could incrementally increase the risk of chronic illnesses such as diabetes, high blood pressure, and cardiovascular disease. If subsistence harvest impacts were limited to isolated, minor events, the sharing networks might be able to compensate to prevent these problems. If, however, harvest disruptions become more common and widespread, serious nutritional health problems could result.

**Infectious Diseases.** The influx of non-resident workers to NSB communities during production activities, coupled with the potential development of new access routes to previously isolated communities, creates the possibility of transmission of pathogens between the NSB residents and people entering the region from outside the region. All NSB villages are isolated – accessible mainly by air. There are two considerations related to the risks associated with infectious disease transmission: (1) the mixing of high and low prevalence groups, and (2) vulnerable populations.

The prevalence of HIV in the Northern Region of Alaska appears to be substantially lower than prevalence in the general U.S. population (ADHSS, Section of Epidemiology 2002, 2007). Risk factors for bloodborne infections include IV drug use and high-risk sexual behavior. HIV transmission rates depend on rates of IV drug use, number of sexual partners, and use of appropriate barrier contraceptives. The prevalence of Chlamydia in the NSB is higher than the U.S. general population, whereas gonorrhea rates are lower. Natural resource development projects such as OCS activities that involving an influx of non-resident workers have the potential to change incidence and prevalence patterns of bloodborne and sexually transmitted infections through the mixing of high and low prevalence populations (IFC 2007; Utzinger et al. 2005).

Respiratory infections can be minor and self-limited (upper respiratory tract infections), or more severe requiring medical attention or hospitalization. However, vulnerable populations – particularly those with

chronic lung disease – are at increased risk of severe complications from contracting even minor respiratory infections. Chronic lung disease is highly prevalent in the NSB. OCS activities in which substantial contact between residents and non-resident workers is anticipated could create conditions in which minor respiratory infections are transmitted between workers and the community, with more serious consequences for community members with baseline pulmonary problems.

**Maternal-Child Health.** Potential effects on maternal-child health from contaminant exposure associated with OCS activities is discussed in section 4.4.1.15.2. A large influx of non-resident workers also has implications for reproductive health. Unplanned pregnancies can be associated with rapid demographic shifts such as occur with resource development (CIT).

**Water and Sanitation.** The NSB budget currently supports water and sanitation infrastructure for coastal villages in the region. OCS revenues would contribute incrementally to the overall revenues available to the NSB for these services.

**Health Services Infrastructure and Capacity.** Health services provided by the NSB are delineated in section 3.4.5. Revenues to the NSB from OCS production activities could contribute incrementally to maintaining these services, but revenues are not projected to be high enough to offset the predicted gradual decline in revenues from onshore development. An influx of non-resident workers to the region could add incrementally to the burden on local health services, and could be a concern if a shorebase were constructed near a village.

**Occupational/Community Health Intersection.** Because some influx of non-resident workers is anticipated, there are a number of issues pertaining to OCS development and the interface between industry occupational health policies and community health that can affect public health. These include:

- The risk of infectious and sexually-transmitted disease transmission between employees and residents. Employee health screening protocols may have an impact on rates of transmission between the community and workers. Similarly, immunization requirements for workers would be an important consideration to ensure that preventable diseases are not brought into the region.
- Illicit trafficking of drugs and alcohol has been reported to occur by residents. Policies of screening for substance abuse disorders, and enforcement policies for drug and alcohol possession by employees are relevant considerations when an influx of non-resident workers is anticipated.

Finally, cultural orientations can be an important means to minimize cultural strain from conflicting values and social conventions when communities interact with non-resident workers

### Potential Effects from Climate Change

Potential climate change effects on subsistence resources and practices were discussed in Section 4.4.1.12.1.9. This section will address the potential effects of climate change in the Arctic on public health.

**Overview.** According to the 4rth IPCC Synthesis Report, "there is *very high confidence* that the global average net effect of human activities since 1750 has been one of warming," and "Most of the observed increase in global average temperatures since the mid-20$^{th}$ century is *very high*" (IPCC, 2007). The IPCC has projected future warming and consequences according to a number of scenarios for economic and technological change. Through this modeling exercise, the IPCC predicts that it is very likely that climate changes in the 21$^{st}$ century will be larger than those observed in the 20$^{th}$ century. Among the IPCC's conclusions with relevance for public health in the 21$^{st}$ century Arctic are the likelihood of more frequent extreme heat waves and heavy precipitation events; widespread increases in permafrost thaw depth;

shrinking summer sea ice; increased precipitation at high latitudes; and more rapid sea level rise. The IPCC also predicted temperature change according to a set of six "stabilization categories," corresponding to 6 levels of stringency in GHG emissions. Temperature rise is predicted to plateau at 2-2.4$^{o}$C in level I (most stringent), compared with 4.9-6.1$^{o}$C under the level VI scenario (Baker et al. 2007). Regarding public health, the report predicts that globally, the health status of millions of people will be affected "through, for example, increases in malnutrition; increased deaths, diseases and injury due to extreme weather events; increased burden of diarrhoeal diseases; increased frequency of cardio-respiratory diseases due to higher concentrations of ground-level ozone in urban areas…; and altered spatial distribution of some infectious diseases" (IPCC 2007.)

The U.S. Climate Change Science Program (CCSP) recently published the "Synthesis and Assessment Product 4.6" (SAP 4.6), an assessment of the likely health effects of climate change in the U.S. (CCSP 2008). Overall, this report found: (1) It is very likely that heat-related morbidity and mortality will increase over the coming decades; (2) urban areas are likely to suffer increases in trophospheric ozone concentrations that can "contribute to or exacerbate cardiovascular and pulmonary illness if regulatory standards are not attained;" (3) "Hurricanes, extreme precipitation resulting in floods, and wildfires also have the potential to affect public health through direct and indirect health risks;" and (4) "There will likely be an increase in the spread of several food and water-borne pathogens among susceptible populations depending on the pathogens' survival, persistence, habitat range and transmission under changing climate and environmental conditions;" and "climate change is very likely to accentuate the disparities already evident in the American health care system" (CCSP 2008).

The SAP 4.6 reports a number of specific problems to which Alaska communities are particularly vulnerable, including (1) extreme precipitation resulting in contaminated water and food supplies in areas with out-dated water treatment plants; (2) wildfires resulting in degraded air quality contributing to asthma and COPD; and (3) "fewer cold waves and higher minimum temperatures," which could reduce cold-related injury. The report cites current impacts of climate change, including an example from Alaska, in which an outbreak of diarrhea caused by shellfish-associated V. parahemolyticus in 2004, which was attributed to the warmest average daily water temperatures recorded in the region (CCSP, 2008; ). The report also highlights the vulnerability of Alaskan coastal community infrastructure to flooding and permafrost melting (CCSP 2008). Perhaps most importantly, the report points out that Alaska Native people in coastal communities are among the most vulnerable to the impacts of climate change not only because of the pronounced effects of climate change on the Arctic physical environment and climate, but also because of their "decreased economic capacity to prepare for and respond to the impacts of change."

The Arctic Climate Impact Assessment (ACIA) analyzed the potential impacts of Arctic climate change on the health of Arctic residents. The report notes the potential that temperature changes (the most probable of which is less extreme cold in winter) could lead to decreased cardiovascular and cerebrovascular events and strokes, and decreased cold injury; increased heat-related morbidity and mortality could also occur, though extreme heat events are not as likely in the Arctic as they are at lower latitudes and in large urban centers (Berner et al 2004). Ozone depletion has long been observed in polar regions, and appears to be increasing. The report discusses the likely contribution of warmer temperature to ozone depletion, and the risks (possible increases in skin cancer and lymphoma, and decreased immune function) (Berner et al., 2004). The ACIA also discussed more complex pathways through which health could be impacted by climate change. For example, climate change has already adversely impacted public health infrastructure (such as solid waste, wastewater, sanitation, and water supply systems, and housing), and this trend is expected to increase; and reduced availability of historically important subsistence species could adversely impact culture, social systems, and health and well-being in Arctic communities. Unpredictable increases in new species (such as Salmon) could offset the loss of key

subsistence species, but would not reduce the cultural significance of a sudden change in availability of a historically important species (Berner et al. 2004).

NSB residents have also observed that the melting of ice cellars has made more frequent hunting trips necessary. Where in the past, for example, a hunter might have brought back a large number of caribou, increased spoilage is now necessitating much more frequent trips. In turn, this represents a large increase in the costs of participating in subsistence, as each trip requires fuel and creates wear and tear on equipment.

OCS oil and gas development would contribute incrementally to climate change, and therefore to climate change-related health effects in the NSB. Incremental contributions to climate change would include GHG emissions from equipment and facilities involved in exploration and production, and combustion of oil and gas produced from OCS development. Current climate change and health models are not precise enough to allow quantification of the contribution of OCS development to climate change-related health impacts. The analysis of the contribution of individual projects and policies to GHG-related effects is a matter of current discussion within federal agencies, and there is little consensus. The IPCC uses 6 well-defined and tested human development scenarios to model climate impacts. High fossil fuel use scenarios – the "A1Fl scenario" in which current trends of increasing use of fossil fuels continue – are associated with the highest risks to human health (IPCC 2008). To the extent that OCS leasing programs are one component of a U.S. energy policy that continues to rely heavily on fossil fuel production, and to the extent that OCS activities facilitate this policy, the Arctic Multisale program would fall into the A1Fl category of emissions, and therefore pose the greatest risk to human health compared with other GHG emissions scenarios.

**General Health and Well-being; Psychosocial/Gender Issues.** The potential loss of key subsistence species, coupled with possible rapid economic and demographic shifts precipitated by changing patterns of industry in the Arctic, and probable damage to housing, public buildings, and water and sanitation infrastructure related to climate change-caused accelerated erosion will pose profound challenges to NSB communities in the coming decades. General health and well-being and psychosocial health would be at particular risk because the remoteness and limited sources of income in NSB communities limit the ability to adapt. There is a potential for increased economic development as a longer ice-free season brings more commerce to the region. However, the potential for increased commercial traffic in North Slope communities would also pose challenges as communities struggle to maintain the integrity of cultural and social systems as well.

**Accidents and Injuries.** Unintentional injury rates tend to parallel psychosocial issues to the extent that over 38% of unintentional injury hospitalizations statewide involve alcohol (ANTHC, 2008). Unintentional injury rates also reflect the very real dangers of a subsistence way of life in Arctic Alaska. One study demonstrated that injury rates increase in proportion to miles travelled by snow machine (Landen et al., 1999). More intense weather events and changing migration patterns could increase the risk faced by hunters. Falling through thin ice is a common cause of injury and mortality in Alaska, and less reliable ice conditions would also increase injury rates. Cold-related injury could decrease as winters become shorter and less severe (Lohman T, personal communication by email, 8/2008).

**Contaminant Exposure.** Global transport of contaminants is highly dependent on climate and weather. The specific effects on contaminant levels in the Arctic cannot be predicted with certainty, but recognizing the likelihood that climate change will alter currently observed baseline levels of contaminants, well-designed and funded monitoring programs will be extremely important to protect subsistence users.

**Food, Nutrition, and Physical Activity; Non-communicable and Chronic Disease.** It is likely the distribution and availability of subsistence resources will change considerably as the Arctic warms, as illustrated by the recent "threatened" listing of polar bears largely because of climate-change related habitat destruction. Climate change also alters communities' ability to harvest resources, because of less reliable ice conditions and more severe weather events. Furthermore available processing and storage methods are already growing less effective, and ice cellars are melting and food spoilage is becoming more common. New species, such as salmon, are being observed in the Arctic, and could offset these losses. The degree and direction of impacts of these changes on nutritional health and chronic disease are uncertain. Other effects on chronic disease include the potential that warmer average winter temperatures could result in somewhat lower cardiovascular mortality, and the potential that photochemical smog could increase and adversely contribute to lung problems.

**Infectious Diseases.** Changing patterns of infectious disease are among the most likely impacts of climate change. New infectious diseases are likely to enter the Arctic as warmer conditions affect the distribution of vectors. Predicted increases in commercial traffic in the Arctic may expose the NSB population to a wider range of infections from world-wide sources. As with the discussion of demographic change above, HIV prevalence is very low in the region, and could increase as commerce with higher-prevalence regions increases.

**Maternal-Child Health.** Changes in contaminant transport and deposition in the Arctic would have implications for rates of birth defects and other pregnancy outcomes such as miscarriages.

**Water and Sanitation.** Water and sanitation effects are discussed in the overview of climate change-related health effects above.

**Health Services Infrastructure and Capacity.** Health services provided by the NSB are delineated in section 3.4.5. The nature and degree of changes that will be seen in the NSB related to increasing commerce in the Arctic are unknown. Certainly, if increased shipping traffic and industrial activity result in increases of non-resident workers or immigrant workers in the region, current health services infrastructure would be strained.

### Mitigation

**Effectiveness of Mitigation Measures.**
Several standard mitigation measures are assumed to be in place for Beaufort Lease Sales 209 and 217 and Chukchi Sea Lease Sales 212 and 221, and this assumption is reflected in discussions below concerning anticipated effects. Mitigation that would apply to subsistence-harvest patterns includes the standard stipulations below. Because no significant OCS activities have begun in the region, the effectiveness of mitigation measures still is largely untested and speculative.

**Stipulation No. 2 – Orientation Program.** Stipulation 2 is described in detail at section 2.2.3.1. Stip. 2 provides for an orientation given to exploration, development, and production personnel. The orientation addresses pertinent environmental, biological, social, cultural, and subsistence concerns. Specifically, it shall be designed to increase the awareness and understanding of industry personnel to local community values, customs, and lifestyles; it shall also include information concerning avoidance of conflicts with subsistence activities; and it shall emphasize compliance with existing environmental protection procedures as they relate to spill reporting and response, fuel storage and handling, proper trash disposal, discharge permits, and the restriction of human interaction with wildlife and subsistence activities.

To the extent that Stipulation 2 proves effective as an educational tool that effectively sensitizes employees to these issues and modifies behavior accordingly, it would be effective in helping to lessen any social tensions that could arise between oil and gas workers and local communities, and in preventing conflicts that could impact local hunters. Accordingly, it would help prevent problems with general wellbeing, social health, and subsistence-related health problems. It would not be expected to eliminate these problems or entirely offset the potential adverse impacts of subsistence harvest failures and entry of non-resident personnel into NSB communities.

**Stipulation No. 5 – An Adaptive Management Mitigation Plan to Protect Subsistence Whaling and Other Marine Mammal Subsistence-Harvesting Activities.** Stipulation 5 is described in detail in section 2.2.3.1. This new measure represents a modification of Stipulation 5 from previous plans. The measure is intended to ensure – through a process of consultation between local subsistence communities, the MMS, and Industry, that impacts to subsistence resources and harvests are minimized. This measure has been considerably revised from that in force for previous lease sales, and the efficacy is not certain. To the extent that it proves effective at preventing subsistence harvest impacts, it would help lower the risk of adverse impacts to general health and wellbeing, psychosocial problems, diet and nutrition, and diabetes and related metabolic disorders.

**Seismic Surveys.** Seismic surveys for geophysical exploration activities would be permitted with existing Alaska OCS exploration stipulations and guidelines and additional specific protective measures. An inability to effectively perform mitigation measures will result in the suspension of a Geological and Geophysical (G&G) permit until such time that the protective measures can be successfully performed and demonstrated. Avoidance planning, stipulations and required mitigation measures under MMPA authorization are defined by NMFS and FWS and would serve collectively to mitigate disturbance effects on Alaska Native lifestyles and subsistence harvests and could therefore mitigate impacts on general health and wellbeing, psychosocial problems, diet and nutrition, and diabetes and related metabolic disorders. The efficacy of these measures would be proportional to their efficacy at preventing losses of subsistence harvest.

**BLM Stipulations and ROPs.** Onshore, BLM performance-based lease stipulations and ROP's for Northeast and Northwest NPR-A leasing actions and Alpine satellite development activity are expected to minimized onshore impacts to subsistence resources and harvest activities and any consequent impacts to public health. The newly signed ROD for the Northeast NPR-A Supplemental IAP/EIS includes several new measures targeting newly identified health effects. These include:

1. The final Preferred Alternative includes the following language:
   > " To help ensure proper consideration of potential health impacts, the BLM will consult with agencies with recognized expertise in Alaska Native public health and health impact assessment on major development proposals to gain information about their potential public health impacts. At a minimum, the agencies to be consulted will include the NSB Health Department and the Alaska Native Tribal Health Consortium." (USDOI BLM 2008).

This measure would help ensure that for any future development and production activities in the planning area, BLM would undertake an adequate evaluation of potential health effects, in concert with accepted sources of expertise and authority on Alaska Native health. To the extent that this recommendation leads to enforceable or voluntarily implemented measures that address any identified health effects, it would prove effective in preventing adverse impacts to health, and in ensuring the maximum benefits of NPR-A development for local communities.

2. ROP A-11

Requirement/Standard: A lessee proposing a permanent oil and gas development shall design and implement a monitoring study of contaminants in locally-used subsistence foods. The monitoring study shall examine subsistence foods for all contaminants that could be associated with the proposed development. The study shall identify the level of contaminants in subsistence foods prior to the proposed permanent oil and gas development and monitor the level of these contaminants throughout the operation and abandonment phases of the development. If ongoing monitoring detects a measurable and persistent increase in a contaminant in subsistence foods, the lessee shall design and July 2008 Appendix B: Modifications and Clarifications 80 Northeast NPR-A Supplemental IAP Record of Decision implement a study to determine how much, if any, of the increase in the contaminant in subsistence foods originates from the lessee's activities. If the study determines that a portion of the increase in contamination in subsistence foods is caused by the lessee's activities, the AO may require changes in the lessee's processes to reduce or eliminate emissions of the contaminant. The design of the study/studies must meet the approval of the AO. The AO may consult with appropriate Federal, state, and NSB agencies prior to approving the study/studies design. The AO may require/authorize changes in the design of the studies throughout the operations and abandonment period, or terminate or suspend studies if results warrant (USDOI BLM 2008).

The rationale for this measure is that "without appropriate safeguards, oil and gas development has the potential to contaminate subsistence foods. Adoption of this ROP will help ensure that the human populations that rely on the planning area for much of their food would not be exposed to harmful levels of oil development-associated contaminants and would limit the risk of contaminant-associated disorders (such as cancers, birth defects, neurodevelopmental delay, and endocrine disorders). This ROP also may help reassure communities of the continued safety of subsistence resources, thereby fostering the continued viability of the subsistence diet and way of life, and help to prevent food insecurity, diabetes, other metabolic syndromes, and social pathology." (USDOI BLM 2008).

3. ROP A-10
Requirement/Standard:
This measure includes the following elements:
a. Prior to initiation of a NEPA analysis for an application to develop a CPF, production pad/well, airstrip, road, gas compressor station, or other potential substantial air pollutant emission source, the lessee shall obtain on-site background air quality and meteorology data to be used in predicting potential future air quality conditions resulting from the proposed action and other Reasonably Foreseeable Future Actions. Monitoring should examine the background concentration of criteria air pollutants. Monitoring data collection must meet BLM standards for quality control and quality assurance before use. (The BLM may consult with the applicant and appropriate federal, state, and/or local agencies to avoid duplication of effort.) The monitoring mechanism for the predevelopment stage would be one that does not require an on-site air polluting emission source. If background data exists that the AO determines is representative of that existing at the proposed development site, the AO may waive this requirement.

b. For developments with a potential for air pollutant emissions as described in subparagraph (a), the lessee shall prepare (and submit for BLM approval) a complete list of reasonably foreseeable air pollutant emissions, including, but not limited to criteria air pollutants and hazardous air pollutants designated under authority of the Clean Air Act, as amended.

c. For developments with a potential for air pollutant emissions as described in subparagraph (a) and informed by the pollutant emissions identified in subparagraph (b), the AO may require air quality modeling using BLM-approved atmospheric dispersion models that are appropriate for local conditions. (The AO may consult with the applicant and appropriate federal, state, and/or local agencies regarding modeling to inform his/her decision and avoid duplication of effort.) The modeling shall compare predicted impacts to all applicable local, state, and Federal air quality standards and increments, as well as

other scientifically defensible significance July 2008 Appendix B: Modifications and Clarifications 79 Northeast NPR-A Supplemental IAP Record of Decision thresholds (such as impacts to Air Quality Related Values, incremental cancer risks, etc.).

d. Depending on the significance of the predicted impacts, a lessee proposing a CPF or other facility with potentially significant impacts on air quality may be required to monitor air pollutant emissions and/or air quality impacts for at least one year of operation. Depending upon the initial monitoring results, the AO may require additional monitoring.

e. If monitoring indicates impacts would cause unnecessary or undue degradation of the lands or fail to protect health (either directly or through use of subsistence resources), the AO may require changes in the lessee's activities at any time to reduce these emissions, such as, but not limited to, use of cleaner-burning fuels or installation of additional emission control systems.

The BLM states the rationale for this measure as: "Through this measure the BLM can ensure that air emissions are not causing unnecessary and undue degradation of air quality and consequent impacts to public health.

ROP I-1, Subparts k and l.
ROP I-1 is a preexisting measure that requires an orientation program for oil and gas-related personnel. BLM added new sub-parts:

> k. Include training designed to ensure strict compliance with local and corporate drug and alcohol policies. This training should be offered to the NSB Health Department for review and comment.
> l. Include training developed to train employees on how to prevent transmission of communicable diseases, including sexually transmitted diseases, to the local communities. This training should be offered to the NSB Health Department for review and comment.

These new orientation requirements, to the extent that they were effective in modifying personnel behavior, would help address concerns of drug and alcohol importation and infectious disease transmission. The new provisions requiring consultation with the NSB health department would be an effective means of addressing health issues at the occupational/community health interface.

### Potential Mitigation Measures to Address Newly Identified Health Effects

During the planning cycle for the 2007 5-year OCS Leasing Program, the NSB, AITC, and MMS held extensive consultations on the subject of public health. Because MMS did not address new mitigation measures at the 5-year Lease Program stage, the MMS and NSB agreed to the following language in the 5-year Final EIS:

> Mitigation for newly identified health concerns will be identified, developed, and considered at the lease sale and permitting stages. In accordance with NEPA and CEQ's implementing regulations and guidance, MMS can work with the appropriate agencies to identify mitigation measures outside of MMS regulatory authority. (USDOI MMS, 2007).

The NSB has joined this MMS for the purposes of addressing the public health effects of OCS leasing. The following potential new mitigation measures were developed collaboratively to address potential health issues associated with the alternatives considered in this EIS.

### 1. Assessment and Mitigation of Potential Health Effects:

Objective: Provide for consideration of public health impacts and mitigation of potential public health impacts when considering future major development proposals.

Potential Measure: MMS would confer with agencies with recognized expertise in Alaska Native public health on activities with potential impacts on public health. At a minimum, these agencies would include

the North Slope Borough Health Department and Alaska Native Tribal Health Consortium. MMS would require lessees in proposals for permanent facilities within the planning area to provide the RS/FO an appropriate analysis of potential public health impacts of the proposal and means proposed to mitigate these impacts as part of any proposal for major permanent facilities. The precise scope of such an analysis would be determined by the RS/FO in consultation with the lessees and the consulting health agencies. It will be done consistent with guidance on NEPA impact analysis found in the NEPA Handbook and general guidance available for health impact analysis (see, for example IAIA 2007; IFC 2007.) MMS would also analyze public health impacts and potential mitigation measures in any NEPA analysis examining such a proposal.

Discussion. The analysis of health effects is required under NEPA and the CEQ regulations on NEPA's implementation (40 CFR § 1500-1508). Several studies, as well as past comments on other EISs in the North Slope, have identified this as an area of relative weakness in current EIA practice in the U.S. (Bhatia and Wernham, 2008; Steinemann, 2000; Cole et al. 2004; USDOI BLM 2007; USDOI BLM 2004). This measure would ensure adequate consideration of public health and mitigation of effects in future OCS activities that occur on tracts leased under this sale, and would in this way be generally protective of health.

### 2. Public Health Baseline Assessment

Objective: Provide for the availability of adequate information regarding the baseline public health status and important influences on the health status of villages affected by OCS activities.

Standard: The MMS Environmental Studies program will fund a baseline health analysis of villages impacted directly or indirectly by OCS activities in the NSB. At a minimum, this study will:

a. Evaluate the health status of villages in the NSB affected by OCS current or anticipated OCS activities. The study will focus on developing appropriate village-level health indicators when possible, and will identify health disparities and vulnerable populations.
b. Identify the likely social, economic, environmental, and behavioral influences on health in OCS communities. In particular, the study will work toward the goal of identifying vulnerabilities and mechanisms of resilience and adaptation in impacted communities.
c. Identify appropriate social, economic, environmental and health indicators for use in monitoring the effects (in terms of health risk and health outcomes) of OCS activities on the health and well-being of NSB communities.
d. To the extent possible using available sources of data, identify the change in these indicators over time.
e. To the extent possible using available sources of data, identify the potential role of oil and gas activities in the region in current health status and changes over time.

The study would provide funds for data review and analysis, village surveys, and a multi-sectoral analysis including economic, biological, and health expertise. NSB, ANTHC, and ASNA would be offered a principal investigator role in this investigation because of their role as the primary agencies charged with public health in the region. In the interest of scientific transparency, all results produced by the NSB and ANTHC or other entity would be fully disclosed for public review at the same time as they were offered to MMS for review and comment.

Discussion: The MMS Environmental Studies program has funded a number of studies of environmental, economic, sociocultural, and subsistence conditions in the North Slope region. To date, these studies have not used health outcomes as a benchmark of OCS impacts and community well-being. The Congressionally-commissioned NRC review of the effects of North Slope oil and gas activities drew attention to health as an area "in great need of additional reliable information" (NRC, 2003). The NSB is currently undertaking a similar study of NPR-A villages. An OCS Environmental Studies project would complement this program, and develop a dataset that would be useful for non-NPRA villages as well.

This would provide the foundation for effective monitoring and mitigation measures for activities occurring on leased tracts in the future.

### 3. Public Health Monitoring

Objective: Monitor the indicators developed through the Public Health Baseline Assessment on a periodic basis before, during, and after the conclusion of OCS oil and gas development activities on leased tracts, to ensure adequate information is available for the MMS and RS/FO to make informed and adaptive decisions regarding management of the region and impact mitigation.

Standard: The measure will require [developers in the region] or [MMS through the OCS Environmental Studies Program] to develop and fund the annual monitoring of a set of health indicators developed through the Public Health Baseline Assessment. These indicators will be chosen for their ability to detect changes in public health and in the recognized social and economic conditions that influence health in the region. The study will be designed to complement rather than duplicate existing public health monitoring programs undertaken in Alaska. In view of the methodological challenges involved in detecting changes in health outcomes in a small population, the study is not expected to be designed to furnish comprehensive monitoring of all potential public health outcomes that could be associated with oil and gas activities. It may require periodic community surveys (examples would include but are not limited to oversampling and additional questions asked in impacted villages during the BRFSS, YRBS, and PRAMS annual surveys conducted by the State of Alaska), but would not require the collection of physical samples or biometric data from human subjects. The goal of this study would be to compile adequate village-level data to detect changes in health status or health risks related to local development activities. Results will be reported annually to the RS/FO, NSB, and ANTHC. The RS/FO will utilize this information to inform performance-based management decisions involving activities within the planning area. To avoid unnecessary and duplicative burdens on lessees and communities, the RS/FO is authorized to approve monitoring plans that combine the efforts of multiple lessees to meet the obligations of each lessee.

Examples of village level data that could be a part of such a plan include but are not necessarily limited to:

- Local arrest rates for index crimes, DUIs, and assault
- Clinic encounters for alcohol and substance abuse-related problems
- Clinic encounters for respiratory problems
- Rates of impaired glucose tolerance
- Clinic encounters for respiratory, gastrointestinal, and sexually-transmitted infections
- Rates of anxiety, depression, and other psycho-social diagnoses.

Rates of health drivers, or determinants, such as high school completion, income disparity, average family income, and participation in subsistence activities.

Discussion and Rationale: OCS activities have the potential to affect the social, economic, subsistence, environmental, and health conditions in villages in the region, as discussed in section 4.4.1.15. As demonstrated in section 3.4.5, there are gaps in current public health monitoring programs regarding village level data, drivers (or determinants) of health, and the relationship between OCS activities and these indicators. As oil and gas exploration and development become more active in the OCS, there will be a need for effective, clear indicators to inform adaptive management strategies that protect and even help promote health in the region. The nexus between health and OCS activities discussed in section 4.4.1.15 provides the rationale for this requirement.

### 4. Subsistence and Nutrition Monitoring and Mitigation

Objective: Prevent health problems resulting from declining subsistence harvests (including diabetes and other metabolic disorders, food insecurity and hunger, social pathology, and injury); protect subsistence resources and harvest levels; prevent undue stress on local economies

Standard: In the Planning Area, the following standards will be applied to permitted activities:

1. *Baseline:* The MMS will fund a baseline nutritional study which will be led by or designed and undertaken in collaboration with the NSB and ANTHC, and which will characterize the harvest and dietary uses of subsistence resources in villages potentially impacted directly or indirectly by the OCS leasing program. The study will complement and will not duplicate harvest studies currently being undertaken by the NSB and ADF&G.
2. *Monitoring*: Lessees will design and implement a harvest and nutritional monitoring study capable of detecting changes in harvest of OCS resources, diet and food security in communities whose subsistence harvest may be impacted by activities occurring on leased OCS tracts. The monitoring interval will be annual. The monitoring study will be designed in collaboration with the NSB and ANTHC, according to accepted best scientific methods for characterizing the diet of mixed subsistence/cash communities. The harvest component will not duplicate other related efforts underway in the region; lessees may collaborate with each other and with the NSB and ADF&G on subsistence harvest monitoring efforts already underway. The RS/FO shall approve study design.
3. *Mitigation*:
    a. The MMS shall require curtailment of activities, if MMS concludes the whale migration or subsistence-harvest of whales or other OCS resources activities are being adversely affected to the level of preventing local subsistence hunters to meet subsistence needs.
    b. If moderate or major subsistence impacts occur, the MMS shall require the lessee to institute additional measures to protect the nutritional health of impacted communities. These measures may include but are not limited to:
        i. Construction and maintenance of community freezers to allow safe, efficient storage of subsistence foods thus ensuring maximally efficient use of successfully harvested resources.
        ii. Fund a hunter assistance program which will be designed and administered by the impacted community(ies) and will be funded at a level that ensures that hunters in the community will have adequate equipment, time, and finances to continue providing for the community. Examples of this type of program include the Maniilaq Association Elder subsistence program, and a number of Canadian hunter support programs reviewed in Aarluk Consulting (2006).
        iii. Fund the implementation of a public health-based plan to prevent diabetes and related metabolic disorders. This plan should include community-based interventions to improve dietary options in communities. The John's Hopkins Healthy Stores initiative is suggested as a model with a proven track record in indigenous communities.

Discussion: Impacts to subsistence harvest and practices may occur secondary to OCS activities, as discussed in section 4.4.1.12., with profound implications for General Health and Wellbeing, Diet and Nutrition, and risk of Chronic Diseases, such as diabetes, metabolic syndrome, high blood pressure, and cardiovascular disease, as discussed under Potential Impacts to Public Health, above. Subsistence is estimated to account for well over 50% of the nutritional intake in impacted villages, although precise baseline nutritional data are lacking. In the case of subsistence impacts, therefore, mitigation is necessary to offset the projected potential reduction in subsistence harvest.

## 5. Air Quality and Health

Objective: Prevent adverse health effects related to airborne pollution from OCS activities.

Measure:
a. Prior to initiation of a NEPA analysis for an application to develop a permanent platform or other potential major emissions source, the lessee shall obtain on-site background air quality and meteorology data to be used in predicting potential future air quality conditions resulting from the proposed action and other Reasonably Foreseeable Future Actions. Monitoring should examine the background concentration of criteria air pollutants. Monitoring data collection must meet MMS standards for quality control and quality assurance before use. (The BLM may consult with the applicant and appropriate federal, state, and/or local agencies to avoid duplication of effort.)

b. For developments with a potential for air pollutant emissions as described in subparagraph (a), the lessee shall prepare (and submit for MMS approval) a complete list of reasonably foreseeable air pollutant emissions, including, but not limited to criteria air pollutants and hazardous air pollutants designated under authority of the Clean Air Act, as amended.

c. For developments with a potential for air pollutant emissions as described in subparagraph (a) and informed by the pollutant emissions identified in subparagraph (b), the MMS may require air quality modeling using ADEC-approved atmospheric dispersion models that are appropriate for local conditions. The MMS may consult with the applicant and appropriate federal, state, and/or local agencies regarding modeling to inform his/her decision and avoid duplication of effort. The modeling shall compare predicted impacts to all applicable local, state, and Federal air quality standards and increments, as well as other scientifically defensible significance standards including in EPA's regulatory analyses for PM2.5 and Ozone that demonstrate health effects that occur below current NAAQS standards. These results will be offered to the NSB for review.

d. Depending on the significance of the predicted impacts, a lessee proposing a CPF or other facility with potentially significant impacts on air quality may be required to monitor air pollutant emissions and/or air quality impacts for at least one year of operation. Depending upon the initial monitoring results, the MMS may require monitoring during the project. This decision will be made through a public consultation process in which the NSB, tribes, and impacted communities will have the opportunity to review modeling results and provide input regarding the need for a monitoring program.

e. If monitoring indicates impacts would cause unnecessary or undue degradation of the OCS environment or health (either directly or through use of subsistence resources), the MMS may require changes in the lessee's activities at any time to reduce these emissions, such as, but not limited to, use of cleaner-burning fuels or installation of additional emission control systems.

## 6. OCS Discharges and Health

Objective: Prevent adverse impacts to subsistence and health from OCS discharges.

Standard: There are two main strategies to ensure that subsistence and public health will not be adversely affected by OCS discharges: (1) use of best practices to prevent discharges; (2) an adequate scientific baseline and monitoring program targeting current deficits in the available database upon which the current regulator strategy is based.

(1) *Discharge prevention:* Proposals for OCS exploration or development projects shall include:
   (a) An inventory of all anticipated discharges; in cases where proprietary products may be used, industry shall provide a list of these substances to the NSB and MMS under a confidentiality agreement that prevents disclosure to the public.
   (b) A thorough assessment of available best practices and technology for preventing discharges;

(c) An analysis of alternatives for minimizing discharges to the OCS environment that shall include, at a minimum, an evaluation of the international best available technology and practices, and an evaluation of the economic and technical feasibility of implementing these measures in the OCS;
(d) An assessment of the data gaps relative to the behavior and fate of discharges in the Arctic OCS relative to data from other marine environments;
(e) Consultation with the NSB, AEWC, and affected communities regarding the findings of this assessment;
(f) Funding provided to the NSB for an independent review of the results of this assessment.

Based on this assessment, applicants shall provide a proposed Discharge Plan to the NSB, AEWC, and local communities for review and comment. The MMS shall fund a review of the discharge prevention plan by the NSB Mayor's Scientific Advisory Council (SAC), which shall have 60 days to review and comment on the plan. The RS/FO shall review the Discharge Plan and comments by community members and the SAC, and shall have authority to impose discharge restrictions in addition to those required under the NPDES General Permit if the MMS concludes that there is reason for concern that subsistence species or users could be harmed, or that data are insufficient to reach a conclusion.

If there is substantial disagreement between the findings of the SAC and the MMS' final decision on allowable discharges, the NSB or affected communities may request they may request that the RS/FO assemble a group consisting of representatives from the subsistence communities, the AEWC, the ABWC, the EWC, the ISC, the ANTHC, the NC, the NSB, NMFS, and the lessee(s) to specifically address conflicts and attempt to resolve the issues before making a final determination on the adequacy of the AMMP to prevent unreasonable conflicts with subsistence harvests. If the parties fail to reach a mutually acceptable resolution, the MMS would agree to engage the U.S. Institute for Environmental Conflict Resolution to resolve disputed issues.

(2) *Baseline data collection:* The MMS shall fund a baseline data assessment and collection program, which will include:
(a) A comprehensive review of the data available to characterize the risks posed to subsistence users and species by planned OCS discharges; this assessment shall clearly delineate any gaps in the database used to evaluate the effects of discharges on the Arctic OCS environment, and any assumptions relied on to reach conclusions regarding the safety of discharges proposed in (1).
(b) A program of baseline environmental studies targeting any identified data gaps.
(c) The NSB Department of Wildlife Management would be offered a role as a principle investigator in this project. If the NSB is unable to undertake this role, all research plans and results would be offered to the Department of Wildlife Management for review and comment.

This baseline study shall be designed to address data gaps, and is not expected to duplicate available, existing programs or data sets.

(3) Based on the discharge plan developed in part (1) of this measure, and the results of the baseline data collection, lessees submitting proposals for OCS exploration or development projects shall:
(a) Develop and implement a proposed monitoring program. The program shall be adequate to characterize:
a. The impact of OCS discharges on physical environment parameters including water quality (concentrations of materials discharged into the OCS that may affect the food web); water temperature and salinity within the discharge zone; and any other parameters necessary to characterize the effects of OCS discharges on the OCS ecosystem as it applies to the health of subsistence resources.
b. Bioavailability of contaminants discharged into the OCS environment and changes in bioavailability of these contaminants over time.

c. Effects on benthic communities that form the basis of the subsistence food chain in the Arctic OCS.
d. Contamination of subsistence foods by potentially harmful substances discharged into the OCS environment.
e. If contamination of subsistence foods is found to occur, developers shall propose a human biomonitoring program. This program would be reviewed by local communities, the NSB Health Department, and ANTHC, and would be implemented on a voluntary basis for affected community members.

The program will be developed in collaboration with the NSB; the NSB shall be allowed to participate as a coinvestigator in data collection and analysis.

Applicants are encouraged to collaborate in the development of monitoring programs, to avoid unnecessary duplication of efforts.

(4) If OCS discharges are found to contribute to the degradation of the local benthic environment, to contaminate subsistence species, or to pose a risk to human populations, the MMS may alter or restrict OCS exploration or development activities.

Discussion: The North Slope environment and communities have several unique aspects that must be considered when evaluating the influence of environment on health. NSB communities have extraordinarily strong ties with and reliance on the natural environment and subsistence resources; residents spend considerable time on the land in subsistence activities, and consume large quantities of locally-harvested fish and game. Fish, game, marine mammals, and other subsistence foods can bioaccumulate pollutants, hence exposure to locally-produced contaminants is a matter of particular concern in local communities. Secondly, the Arctic environment and Arctic OCS ecosystem are markedly different from other regions where much data on OCS discharge impacts has been collected. Finally, Alaska Natives in the NSB region have high rates of cancer and lung disease, both of which may be associated with exposure to environmental pollutants. This measure would ensure an evaluation of baseline conditions, monitoring of changes that could affect health, and an appropriate, region-specific management plan that reflects the particular vulnerabilities of the population and addresses present data gaps.

## 7. Stipulation 2 – Additions pertaining to health

Objective: address public health concerns through orientation and training for employees in OCS oil and gas-related jobs:

Standard: The following provisions would be added to Stipulation 2:
Include training designed to ensure strict compliance with local and corporate drug and alcohol policies. This training should be offered to the NSB Health Department for review and comment.

Include training developed to train employees on how to prevent transmission of communicable diseases, including sexually transmitted diseases, to the local communities. This training should be offered to the NSB Health Department for review and comment.

Discussion: These new orientation requirements, to the extent that they were effective in modifying personnel behavior, would help address concerns of drug and alcohol importation and infectious disease transmission. The new provisions requiring consultation with the NSB health department would be an effective means of addressing health issues at the occupational/community health interface.

## 8. Socioeconomic Monitoring and Mitigation Plan

Objective: Protect and promote public health through identifying and mitigating health impacts related to socioeconomic and demographic changes associated with OCS oil and gas activities.

Standard: The NSB could develop a permit condition for incorporation into its Municipal Code that address the potential social, economic, and health costs associated with the presence of facilities, personnel, and equipment associated with OCS activities. The measure would be patterned on similar measures such as the Santa Barbara Tri-County Socioeconomic Monitoring and Mitigation program, but would be adapted to the particular conditions of the NSB. This measure would attempt to develop quantitative measures of social and economic change caused by OCS activities, and the expenses to the NSB. Examples of parameters that could be addressed include but are not limited to:

- Incremental wear and depreciation of public infrastructure (runways, roads, water supply and sanitation systems);
- Influx of non-resident workers resulting an increased demand for services (school, water/sewer, police services);
- Population change, and the costs for local communities associated with immigration of non-resident workers, and outmigration of residents;
- Rates of EMS service calls;
- Police reports;
- Local inflation;
- An estimate of the economic costs associated with displacement of subsistence resources (costs of purchasing food; increased fuel expenses and wear and tear on subsistence equipment.

The plan would develop a formula to calculate costs associated with these parameters. Industrial developers would be required to reimburse the NSB for these costs on a periodic basis under the terms of the permit condition (Powers et al., 2000).

The development of an adequately detailed permit condition would require significant resources. Funds from the CIAP could be used for initial development of this measure. The MMS does not have jurisdiction over onshore impacts, but recognizes the potential that the "hidden" costs associated with OCS activities could have serious implications for socioeconomic conditions and would agree to moderate a series of conversations between industrial proponents and the NSB to ensure satisfactory implementation.

Discussion: The influx of personnel, economic and employment changes, and onshore movements of equipment associated with OCS activities create demands on local services and infrastructure, as well as impacts on subsistence, as discussed in section 4.4.1.13 and 4.4.1.15 and subsections (see also Powers et al, 2000). This measure would compensate the NSB according to the results of a quantitative socioeconomic monitoring program, to ensure that the NSB is able to maintain services and infrastructure adequate to the demands placed on it.

### 9. Siting of Shorebases, roads, and pipelines onshore

Objective: For the planning and permitting of shorebases, roads, and pipelines, ensure that the NSB and local communities are able to influence decisions to protect health. Specifically, this measure would require developers to develop plans for onshore facilities supporting OCS oil and gas development and production in collaboration with the impacted communities.

Standard: The NSB could develop a new permit condition requirement within its Municipal Code that requires a process of health impact evaluation for the construction of new roads into villages, new facilities or shorebases, bridges, and pipelines in new areas. The health impact evaluation would require the evaluation of potential health impacts and benefits across a range of alternatives for the proposed construction. Additional authority could be generated through the NSB's CZMA.

Alternatively, this measure could be instituted through voluntary collaboration between industry and the NSB. The MMS could host meetings between the parties to facilitate a voluntary approach.

Discussion: New roads into NSB villages could change social conditions and health outcomes considerably. The villages would have road access to urban centers, which could compromise the efficacy of local prohibition laws, and strain existing law enforcement, health care, and EMS services. Similarly, a shorebase near a village might increase interactions with non-resident personnel, and could lead to social health/well-being problems and infectious disease transmission. On the other hand, it must be recognized that roads and shorebases offer considerable benefits for local villages, including economic opportunity, access to urban areas. A health-focused analysis and management plan could help give villages the opportunity to consider a number of scenarios and work toward a balanced, health-focused plan.

### 10. Climate change, OCS activities, and Subsistence

Objective: Prevent adverse health effects from subsistence impacts caused by a combination of OCS activities and climate change.

Standard: Lessees [or MMS?] will fund the construction and operation of community freezers in communities affected by OCS activities.

Discussion: The cumulative effect of OCS oil and gas activities in the context of climate change-caused changes on the North Slope poses several specific challenges for NSB subsistence practices. (1) Hunters sometimes have to travel farther because of displacement of subsistence resources. This has reportedly increased the risk of spoilage of foods in the process of returning them to the village, processing, and storing them. (2) Ice cellars are thawing, resulting in more rapid food spoilage. To compensate, hunters are having to hunt more frequently, incurring additional expenses to travel in search of food. This measure would improve the supply of harvested food through helping to prevent spoilage of successfully harvested resources.

### 11. Noise and Public Health

Objective: Prevent adverse health effects from aircraft noise related to OCS activities.

Standard: The FAA could require that any project involving 2 or more flights per day over, landing in, or launching from an existing community shall be responsible for noise-related monitoring and mitigation as follows:

a) For any project on leased tracts that is anticipated to or involves an average of 2 or more flights per day to, through, or from an NSB village, the lessee shall be responsible for preparing a baseline assessment of ambient noise in the village. The baseline assessment shall determine indoor and outdoor ambient noise levels, including (i) the 24 hour average ambient noise baseline levels in the village; (ii) average school-hour values; and (iii) average nighttime values, and will differentiate indoor from outdoor levels. If ambient noise levels are found to be above 40 dB(A) indoors or 50 dB(A) outdoors, lessees will be required to monitor noise levels as detailed in c). If ambient indoor, outdoor, 24 hour, school-hour, or nighttime noise levels are below these thresholds, lessees will be required to undertake the measures detailed in b).
b) The lessee will model the anticipated contribution of the proposed activity to overall noise levels in the village using an FAA-approved noise model. If the result indicates a risk that cumulative ambient noise levels during any time period outlined in a) will exceed safe thresholds, the lessee will undertake a baseline noise assessment and modeling as described in a), and monitoring as described in c). If the result indicates that ambient noise levels will remain below safe thresholds, no further monitoring will be required. In this case, lessees will submit to the RS/FO a monthly

list of all flights to, from, or over the village. If for any 1 month period, the number of flights exceeds that anticipated in the proposal, the lessee will undertake baseline monitoring as in a).

c) If required under b), the lessee shall monitor ambient indoor, outdoor, 24 hour, school-hour, or nighttime noise levels over the course of the project.
d) If at any time the lessees' actions contribute incrementally to unsafe noise levels in a village, lessees will be required to develop a noise mitigation plan. Elements of such a plan could include but are not limited to:
    i. Alteration of flight paths.
    ii. Coordination with the village government to determine the least disruptive hours for flights.
    iii. Residential and school soundproofing retrofitting.
    iv. Construction of an airstrip and base of operations adequately separated from the community to reduce village noise levels to acceptable threshold.

## Anticipated Effects on Public Health

The potential effects to public health were discussed in section 4.4.1.15.1.2. This section describes the impact on public health resulting from the incremental impact of this action, Alternative 1 No Lease Sale, and adding it to other past, present, and reasonably foreseeable future actions regardless of what agency or entity undertakes such actions. Past and present cumulative actions are described below as they have impacted specifically affected pubic health. This section incorporated the BLM's review of past and present cumulative effects on public health from the recent Northeast NPR-A FEIS (USDOI BLM 2008).

**General Past and Present Effects.** Impacts to the health of the North Slope Inupiat people have occurred since the first direct interactions with people from outside the region. Beginning with Russian fur traders in the 1700s, the early contact era was characterized by the introduction of epidemic infectious diseases. Early measles and smallpox epidemics resulted in a substantial population decrease and persisted into the early 1900s. In the early 1900s, pandemics of influenza and tuberculosis resulted from contact with whalers and the concentration of population in larger and more sedentary centers. A pandemic of influenza in 1918 dramatically reduced the Inupiat population in some villages, particularly around Norton Sound. Epidemic infectious disease was eventually largely controlled through intensive public health interventions and improved living conditions and sanitation beginning in the 1950s (Goldsmith, 2004).

Commercial whaling north of the Bering Strait began and ended in approximately 60 years. In addition to the associated infectious diseases, it resulted in the introduction of new foodstuffs (e.g., flour, sugar, coffee, and tea), the increased availability of alcohol and tobacco, ongoing efforts at acculturation of the Iñupiat through missions and government schools, and efforts to centralize and make sedentary the highly mobile Iñupiat populations. The changes initiated during this time formed the early basis of the changes in health status described in section 3.4.5, namely, a trend toward increases in chronic metabolic diseases, cancer, and social pathology, accompanied by general improvements in life expectancy and infant mortality.

The dietary, cultural, and health changes experienced since the 1950s are similar to general trends observed in circumpolar other Inuit communities. Studies have linked modernization and acculturation with increases in metabolic disorders such as diabetes, cardiovascular diseases, cancer, and social pathology such as domestic violence, alcohol and drug abuse, and suicide (Bjerregard 2001; Curtis, Kvernmo et al 2005; Krauss & Buffler 1979; Shepard and Rode, 1996). The extent to which oil and gas development may have contributed to these trends has never been investigated directly and is incompletely understood, but potential causal pathways can be identified, and local testimony strongly suggests a causal connection between many of the changes in health status – both positive and adverse – and oil and gas development.

General health indicators – such as infant mortality and life expectancy – have improved over the last 40 years. Revenues from oil development support the NSB as the region's top employer, and income from Native Corporation dividends and employment (particularly in Nuiqsut) support a generally higher economic standard of living, employment opportunities, and public health and sanitation infrastructure, all of which are associated in the public health literature with improved population health status.

But despite these improvements in overall mortality figures, significant disparities remain in terms of overall health status, and cancer, social pathology, and chronic diseases are rapidly increasing. Life expectancy at birth for Alaska Natives remains significantly lower than for the general population (69 compared with 76 years). Since 1979, Alaska Native mortality rates remain roughly 1.3 times higher than the U.S. population, and on the North Slope, overall mortality rates are roughly 1.5 times higher than the U.S. population. Rates of assault, domestic violence, and unintentional and intentional (homicide and suicide) injury and death in the North Slope remain far higher than in the general U.S. population, despite the improvements in unintentional injuries delineated in Chapter 3.4.10 (Lanier et al., 2002; Day et al., 2006; Goldsmith et al., 2004; U.S. Department of Health and Social Services, 2006).

No studies have directly addressed the complex question of how oil and gas development has contributed to shaping general health status in the region. This question was identified as one of the areas in greatest need of additional information in a congressional review of the effects of oil and gas development on the North Slope (NRC 2003). Public testimony on prior EISs in the North Slope region has indicated a concern that oil and gas development in the region may be at the root of some of the health disparities described in this section. As stated by former North Slope Borough Mayor George Amaogak, for example:

> "The benefits of oil development are clear – I don't deny that for a moment. The negative impacts are more subtle. They're also more widespread and more costly thatn most people realize. We know the human impacts of development are significant and long-term. So far, we've been left to deal with them on our own. They show up in our health statistics, alcohol treatment programs, emergency service needs, police responses – you name it" (Ahmaogak 2004).

Socioeconomic status – as measured by income, education, or employment variables, is powerfully associated with both population health indicators – such as life expectancy and overall mortality rates – and rates of individual diseases such as cancer and cardiovascular disease (Adler and Newman, 2002; Pamuk et al. 1998). This association led the Director of the U.S. National Cancer Institute to observe that "poverty is a carcinogen" (Broder, 1991), and has been observed for almost every cause of morbidity and mortality, from injury to problems such as cancer and heart disease. Access to health care, while important, is estimated to account for only approximately 10% of the overall variation in disease rates between economic and ethnic subpopulations in the U.S. (Schroeder, 2007, McGinnis et al., 2002). To the extent that North Slope oil and gas activities have become the dominant economic force in the region, it is certain that they have impacted health.

For indigenous peoples, the links between measures based on a cash economy and western education, and health are complex. While adequate financial resources and employment are undisputedly important to community well-being, there is also broad agreement that factors related to socio-economic change, such as, for example, cultural disintegration, loss of indigenous languages, and growing contribution of modern convenience foods to the diet in rural villages, for example, have contributed to current health disparities noted in indigenous people throughout the world (WHO, 2007, Poppel et al., 2007). In the North Slope region, several studies have addressed questions of the effect of living conditions on well-being. The recently completed Survey of Living Conditions in the Arctic (SLiCA) found that higher levels of income

were not linearly associated with measures of well-being. In this sample, independent of income, 44% of surveyed participants who were categorized as "most active" in subsistence said they were "very satisfied" with their lives, compared with only 30% of those in the "least active" group. The contribution of socioeconomic factors to specific health problems will be reviewed in more depth in subsequent sections.

Public testimony on prior EISs in the region has indicated a persistent concern that regional industrialization may be at the root of some of these persistent health disparities. For example, testifying in 2001 on the MMS' Liberty DEIS, Rosemary Ahtuangaruak, a former health aide who received advanced training as a physician's assistant, stated:

> Increased incidents of community social ills associated with rapid technological and social change cause problems with truancy, vandalism, burglary, child abuse, domestic violence, alcohol and drug abuse, suicide, and primarily the loss of self-esteem. This has materialized during transient employment cycles. The influx of construction workers bring their own problems to a village impacted by oil development activities already. Historically, from past experience, we know that the incidents of alcohol and drug use increase dramatically (USDOI MMS, 2001).

Concerns regarding the contributing role of oil and gas development to social pathology are well-founded in accepted mechanisms of health and illness, as well as public health data. For example, residents have expressed concern that increasing ice road access or eventual gravel road access to previously isolated communities, and the influx of oil workers from outside these communities, may lead to increases in drug and alcohol trafficking. Data has shown a strong correlation between effective prohibition, adequate law enforcement and better health outcomes in Alaska Native villages (Wood and Gruenewald, 2006; MMS, 2001); anything which would compromise the efficacy of local prohibition would thus exacerbate alcohol, drug, and social problems in the impacted community. Similarly, residents have noted the very direct link between oil and gas activities, impacts to subsistence, and the resultant stress and maladaptive coping mechanisms which have deepened social pathology in the villages. Data indicate a strong link between the integrity of subsistence and sociocultural traditions and health (for example, Curtis, Kvernmo et al., 2005; Wexler, 2006). Thus, to the extent that oil and gas development at Prudhoe Bay, Kuparuk, and other fields east of the Colville River has created more difficult subsistence conditions and has eliminated previously culturally and practically important areas from use, social pathology may have been exacerbated. One study demonstrated a clear link between acculturation pressure and suicide in Inupiat communities, but made the point that this effect is mitigated to some extent by economic development (Travis, 1984). Thus, the economic benefits of oil development may to some extent offset the adverse social pathological impacts of development.

Injury rates reflect not only the challenges of subsistence life in the Arctic but also the contribution of social pathology, which lead to problems such as domestic violence and suicide, as well as alcohol and drug abuse which increase the risk of accidents as well as violent behavior. Injury rates on the North Slope have been decreasing over the last 40 years, but remain far higher than rates in the general population (ANTHC, 2006; Day et al., 2006). Much of the decrease in injury rates is attributed to aggressive public health intervention campaigns such as helmet education programs, and to effective prohibition laws and enforcement. Impacts of oil and gas development on social pathology would have predictable effects on injury rates. Also, as oil infrastructure has encroached on and displace subsistence resources, residents have had to travel farther at times for successful hunts. Longer travel times result in statistically increased chance of injury as well.

Dietary change may result not only from impacts to subsistence resources, but from increased availability of convenience foods in stores, increases in income, and alterations in the cultural preference for foods. Data indicate that the overall per capita subsistence harvest in the North Slope remains robust, and among

the highest in Alaska, and that income related to past oil development may in part facilitate subsistence (ADF&G, 2000; Kruse & Braund, 2004, in press). But diabetes appears to be increasing rapidly in the Inupiat as discussed in 3.4.7.5 and 3.4.7.6, owing to dietary change and a more sedentary lifestyle. Data shows that influences which lead to modernization of Arctic communities in general result in lower consumption of subsistence foods (Bjerregaard, Jorgensen et al., 2004; Schraer and Bulkow, 1993). The transition toward a 'modern' diet is occurring to various extents throughout the state of Alaska, owing to socioeconomic changes which have occurred at the state level. The specific contribution, then, of oil and gas activities on the North Slope is not possible to quantify. However, because of both the displacement of subsistence resources and hunters, and the large-scale local economic changes produced by oil development, it is reasonable to infer that oil development is playing a role in local dietary change.

Residents have also expressed concern over the marked increase in pulmonary disorders such as asthma, certain types of cancer, and thyroid disease; many worry that these problems result from environmental contamination related to local industry. Data are not sufficient to analyze these concerns. Residents in Nuiqsut have complained that local gas flaring at the Alpine facility has led to increased respiratory problems in the village. One brief unpublished review examined rates of asthma and other lung problems including lower respiratory tract infections (such as pneumonia) in Nuiqsut compared with a control village, and found differences only in the 10-19 age group, and in the number of clinic visits for asthma (Serstad and Jenkerson, 2003). Health care providers interviewed for this study noted that an apparent increase in respiratory problems may have correlated with increased traffic on the roads leading to increased dust, although the study findings did not support nor conclusively refute this hypothesis.

Oil and gas development operations would emit air pollutants that are respiratory irritants, such as NOx, SOx, and fine particulate ($PM_{2.5}$), and can lead to higher levels of ground-level ozone. However, air quality monitoring in the North Slope has not included data on $PM_{2.5}$, one of the main environmental contributors to respiratory and cardiovascular illnesses. In addition, a detailed inventory has not been conducted for hazardous air pollutants (HAPs), a diverse group of contaminants associated with an array of human health effects including carcinogenesis, birth defects, learning disabilities, and endocrine disruption, as well as an etiologic role in asthma (AMAP 2003; Miller et al. 2004). Furthermore, as discussed in the Air Quality analysis, intercontinental transport of airborne pollutants renders the attribution of air quality impacts to local sources even more complex. Finally, monitoring and reporting requirements for HAP do not require measurement of the accumulation of HAP in ground, vegetation, or animal populations. For these reasons, it is not possible to model the potential contribution of local industry to health problems with accuracy. However, smoking rates are high on the North Slope, and likely contribute to the prevalence of pulmonary disease and specific cancers such as lung cancer. And although incomplete, data on some subsistence foods in the region appear to demonstrate that the subsistence food supply in the North Slope region is relatively safe (O'Hara, Hoekstra et al., 2005; Alaska Department of Public Health, 2004a and 2004b; AMAP, 2003). Nevertheless, given the preexisting health disparities and vulnerabilities in this population, and their extraordinarily high consumption of local subsistence resources, the potential contribution of contaminants is a serious concern. While studies linking the prevalence of specific health problems to locally-emitted contaminants would be limited by the small sample size, public health experts advocate stringent controls on exposure.

**Reasonably Foreseeable Future Effects.** Ongoing projects in the region are summarized in Section 4.2.1, and include: (1) ongoing maintenance and development projects in local communities; (2) onshore oil and gas infrastructure development; (3) passenger, research, and industry-support aircraft activities; (4) local boat traffic, barge resupply to local communities, research vessel traffic, industry-support vessel activities (mostly in support of seismic surveys), an increasing U.S. Coast Guard presence, and vessel traffic from increasing ecotourism in the Arctic. Ongoing actions include: (1) development and production activities at Endicott, Northstar, Badami, and Alpine; (2) recent leasing from Beaufort Lease Sales 195 and 202; (3) State leasing; and (4) onshore leasing activity in the NPR-A. Other projects

include BP's restart of the Liberty Development Project east of Endicott; Pioneer Natural Resources Co.'s development of its North Slope Oooguruk field in the shallow waters of the Beaufort Sea approximately 8 mi northwest of the Kuparuk River unit; and the Nikaitchug Development Project also in State waters off the Colville Delta. In Canadian waters, Devon Canada Corporation is planning to do exploratory drilling off the Mackenzie River Delta, and GX Technology Corporation will conduct a 2D seismic survey in the Mackenzie River Delta area (USDOI, MMS, 2006a).

Impacts to subsistence resources and harvests from existing and planned oil and gas exploration and development, potential increased boat traffic from ecotourism and commerce in the Arctic, environmental contamination, influx of non-resident workers and ecotourism; staging for OCS activities from shorebases, airstrips, and communities; and on-going changes in the Arctic climate, will have impacts on public health in the NSB in the foreseeable future. Onshore development already has caused increased regulation of subsistence hunting, reduced access to hunting and fishing areas, altered habitat, and intensified competition from non-subsistence hunters for fish and wildlife (Haynes and Pedersen, 1989). Additive impacts that could affect subsistence resources include potential oil spills; seismic noise; road and air traffic disturbance; and disturbance from construction activities associated with ice roads, production facilities, pipelines, gravel mining, and supply efforts. Diverting animals from their usual and accustomed locations, or building facilities in proximity to those locations, could compel resource harvesters to travel further to avoid development areas. Harvest of subsistence resources in areas farther from the local subsistence communities would require increased effort, risk, and cost on the part of subsistence users. Increasing onshore areas open for leasing and exploration would lead to development in previously closed areas, leading to concentrating subsistence-harvest efforts in the undeveloped areas and increasing the potential for conflict over harvest areas within a community (USDOI, BLM, 2005). Mitigation, such as the AMMP and IHA, should reduce these impacts. However, as highlighted by the NSB in the recent Open Water meetings of 2008, these measures are untested at the increased levels of activity, and available data are not adequate to characterize the likely response of marine mammals to multiple concurrent exploration and development-related activities occurring at various points along the migration route with increased frequency and noise intensity. Furthermore, it must also be acknowledged that neither the AMMP nor the IHA address frequent community concerns regarding OCS contaminants; if OCS discharges and emissions undermine the confidence of subsistence users in the safety of key OCS resources, impacts on subsistence would be major. As described on page J46 and subsections, subsistence is the cornerstone of health and wellbeing in NSB communities; impacts to subsistence carry serious implications for general health and wellbeing, psychosocial health, nutrition and dietary health, and patterns of chronic disease; influx of non-resident personnel, shorebases, and new access routes to communities create a route for infectious disease transmission and could trigger increases in diseases, such as HIV, which are currently rare in the region; environmental contamination could become an increasing problem as industrialization spreads toward population centers and key subsistence habitat; economic impacts on health are mixed, as described on page J18., but it is likely that as revenues decline from their peak, the NSB will face a period of contracting services, with profound implications for services and infrastructure that currently protect health and safety in NSB communities.

## Anticipated Effects from Disturbance

The potential effects on public health from disturbance were discussed on page J9; see also the general discussion on anticipated effects to public health in section 4.4.1.15.

Effects on public health from disturbance derives primarily from impacts to subsistence resources, which is discussed in Section 4.4.1.12.1. These actions would be expected to impact public health – particularly general health and well-being, nutrition and diet, and chronic diseases such as diabetes, high blood pressure, and cardiovascular disease – to the extent that subsistence resources are impacted. The cumulative effects on bowhead whale migration are a particular concern, and could lead to decreased subsistence harvest and even potentially to quota restrictions by the IWC if the effects of industrialization

increase the cumulative threat to this species. Any substantial decrease in bowhead whale harvest would constitute a major impact on public health. Alternative 1, the no-action alternative, would not contribute substantially to the cumulative effects on public health from disturbance.

**Anticipated Effects from Discharges.**
Potential effects from discharges on public health were discussed on page J9.

Effects on subsistence resources from exploration were projected to be mild to moderate. As delineated in section 4.4.1.3.17.5.2, however, the acknowledged data gaps regarding the fate and impacts of OCS discharges on Arctic subsistence species is a source of considerable concern in NSB communities. Discharges could lead to perceived risk of contamination that would adversely impact residents' confidence in the safety of the food supply, alter harvest and consumption patterns, and increase the risk of nutritional deficiencies, food insecurity, and chronic diseases such as diabetes, high blood pressure, and cardiovascular disease, a major effect. Contaminants associated with oil and gas activities are associated with a range of public health problems, including cancer and neurodevelopmental delay as described under potential effects. Alternative 1, the no-action alternative, would not contribute substantially to the cumulative effects on public health from discharges.

**Mitigation.** Mitigation could reduce the adverse effects from discharges on public health. Onshore, the BLM's new ROP A-11 will provide subsistence users with valuable information regarding the levels of contaminants in land-based resources, and would provide a mechanism to ensure a regulatory response if levels of local contaminants were found to reach levels that could harm subsistence users. MMS Potential Mitigation Measure 6, OCS Discharges and Health, would create a monitoring and discharge control framework specifically tailored to address the fate and accumulation of contaminants given the unique ecosystem of the Arctic OCS environment, and the extraordinarily high consumption of animal tissues among subsistence users. MMS Potential Mitigation Measure 1 would ensure that major OCS projects addressed potential health effects and developed mitigation plans. Potential Mitigation Measures 2 and 3 would ensure an adequate database and ongoing monitoring of public health measures, which would allow the assessment of both discharge-related health effects and of the efficacy of mitigation measures developed to protect health.

### 4.4.1.3.17.1.1 Anticipated Effects from Large Oil Spills
Potential effects on public health from large oil spills were discussed at section 4.4.1.3.17.5.3.

The effects from large oil spills on subsistence resources and practices were discussed in Section 4.4.1.3.12.12 and the effects from large oil spills on sociocultural systems were discussed in section 4.4.1.3.13.8.3. A large oil spill could adversely effect public health would be expected to impact sociocultural systems to the extent it adversely impacted subsistence harvests and practices. Following the EVOS, communities experienced increases in post-traumatic stress disorder, depression, anxiety, and stress (Palinkas et al., 1993; Palnikas et al., 2004), decreased social interconnectedness (or social capital) (Ritchie and Gill, 2004), and decreased subsistence harvests that persist to this day (day (Fall and Utermohle, 1995; Impact Assessment, Inc., 1998; Field et al., 1999; USDOI, MMS, 2003a; USDOI, BLM and MMS, 2003). The effects of contaminant-related health effects related to an oil spill are difficult to study. For example, exposure to benzene and other HAP for those near a spill could be high enough to increase the risk of rare cancers such as leukemia. However, because of the small population size in NSB villages, linking a change in incidence of such a cancer to an environmental exposure is statistically difficult. Nevertheless, for contaminants with well-characterized toxicological profiles such as benzene and specific PAH, exposure is know to produce adverse health effects, and should be considered a major adverse health effect of a large spill if individuals or communities are exposed. Alternative 1, the no-

action alternative, would not contribute substantially to the cumulative effects on public health from large oil spills.

**Mitigation.** Mitigation could reduce the effects of a large oil spill on public health. Potential new mitigation measures for public health are discussed in section 4.4.1.3.17.6.2. Mitigation would not be expected to prevent or eliminate adverse health effects from a large spill, but would be a critically important part of an adequate response. Potential mitigation measure 3, public health monitoring, would create a mechanism through which the public health effects of a large spill could be tracked, which would facilitate an adequate response from the public health and health care systems. Potential mitigation measure 4 would track nutritional impacts from a large oil spill, and requirements for measures that would help protect the nutritional health of residents.

### 4.4.1.3.17.1.2 Anticipated Effects from Oil-Spill Response and Cleanup

The potential effects on public health from oil spill response and cleanup were discussed at section 4.4.1.3.17.5.4.

Cumulative effects from oil-spill response and cleanup on subsistence resources and practices were previously discussed in Sections 4.4.1.3.12.12. Based on the EVOS, residents employed in cleanup could stop participating in subsistence activities, have a lot of money to spend, and tend not to continue working in other lower paying community jobs. In the event of a much larger spill, these dramatic changes could cause tremendous social upheaval, with implications for health as described in section 4.4.1.3.17.5.4 (Human Relations Area Files, Inc., 1995; ADF&G, 1995b; Impact Assessment, Inc., 1990c, 1998). These changes have important implications for health. The rapid influx of cash, influx of non-resident workers to and through coastal communities, and short-term and unstable employment increase the risk of infectious disease transmission, potentially compromise the efficacy of local prohibition laws in preventing adverse health effects from alcohol consumption, and could exacerbate social and psychological strain leading to maladaptive behavior including violence and alcohol and drug abuse. The adverse health effects of insecure or unstable employment are similar to unemployment in many studies (Marmot and Wilkinson, 2003). Interference with subsistence seasonal activities would have implications for nutritional health and chronic diseases such as diabetes, but as oil spill response would be a short-term event, would not be expected to contribute significantly to the risk of these conditions developing. Alternative 1, the no-action alternative, would not contribute substantially to the cumulative effects on public health from oil-spill response.

### 4.4.1.3.17.1.3 Anticipated Effects from Airborne Emissions.

Potential effects from airborne emissions on public health were discussed in section 4.4.1.3.17.5.5.

Most of the emissions from North Slope development have to date been concentrated in the region of Prudhoe Bay. Emissions from Prudhoe Bay have been detected in Barrow (Jaffe D, Honrath R et al., 1995). According to the Alaska DEC, “transport and deposition of pollution downstream of the North Slope facilities may be having a noticeable effect on the environment of the NPR-A. Currently, no data has been collected to document if the substantial amount of pollution emitted on the North Slope, although not in violation of air standards, may be having a significant cumulative effect on this area” (ADNR, 2007). Monitoring data are not sufficient to allow determination of the contribution of current oilfield emissions to air quality in Barrow or other villages remote from Prudhoe Bay, relative to the contributions of other known sources in Northern Europe and Asia. EPA Criteria Pollutants have been associated with an array of health effects, the most common and significant of which include causing and exacerbating respiratory illnesses such as asthma; increased risk of cardiac arrhythmias; exacerbated atherosclerotic coronary artery disease; and excess overall mortality among vulnerable groups. According to the EPA, $PM_{2.5}$ in particular is associated with “increased respiratory symptoms, such as

irritation of the airways, coughing, or difficulty breathing, for example; decreased lung function; aggravated asthma; development of chronic bronchitis; irregular heartbeat; nonfatal heart attacks; and premature death in people with heart or lung disease" (EPA 2005). According to EPA analysis and several independent studies, substantial health effects from fine particulates accrue at even levels below NAAQS standards, down to ambient levels, and are particularly dangerous for those with chronic lung disease and cardiovascular disease. The effects of BTEX such as benzene and PAH include specific types of cancer, lung disease and mutagenesis. Current data are not adequate to quantify the risk posed by emissions from past and present industrial activity in the NSB on pubic health. This question of health effects from airborne contaminants must be viewed, however, in the context of other known risk factors such as indoor air quality, dust, emissions from local sources such as power plants and vehicles, and the burning of refuse. In general, major emissions sources for OCS exploration would be distant from communities, and so the incremental contribution of OCS activities to air quality in population centers would be relatively small. On the other hand, subsistence users near or downwind from OCS emissions sources could suffer effects from short term exposure to criteria pollutants and HAP; and, the actual contribution of major OCS sources to onshore/village pollution levels would depend on the nature and amount of emissions, climate conditions, and prevailing winds. Alternative 1, the no-action alternative, would not contribute substantially to the cumulative effects on public health from airborne emissions.

#### 4.4.1.3.17.1.4 Anticipated Effects from Seismic Surveys

The potential effects from seismic surveys on public health were discussed in Section 4.4.1.3.17.5.

Cumulative effects to bowhead whales and other marine mammals is a serious concern. If increased noise affected whales and caused them to deflect from their normal migration route, they could be displaced from traditional hunting areas and the traditional bowhead whale harvest could be adversely affected. The same could be true for beluga whales, walrus and seals (USDOI, MMS, 2003a). The disruption of bowhead whale harvests could result from any potential diversion of the whale migration further offshore, or from other behavior changes by the animals—making them more skittish, for example—in reaction to OCS activities. The greater the degree of activity onshore and oil and gas development in Federal, State, and Canadian waters, as measured by increases in seismic noise, vessel traffic, east-to-west development, Canadian activities in the Mackenzie Delta, or some other metric, the more probable and more pronounced cumulative effects are likely to be. If the IWC considers the threat of industrialization large enough, it could reduce the Alaska bowhead whale quota to protect the stock. Mitigation, such as the AMMP and IHA, should reduce these impacts. However, as highlighted by the NSB in the recent Open Water meetings of 2008, these measures are untested at the increased levels of activity, and available data are not adequate to characterize the likely response of marine mammals to multiple concurrent exploration and development-related activities occurring at various points along the migration route with increased frequency and noise intensity. Furthermore, it must also be acknowledged that neither the AMMP nor the IHA address frequent community concerns regarding OCS contaminants; if OCS discharges and emissions undermine the confidence of subsistence users in the safety of key OCS resources, impacts on subsistence would be major.

The cumulative effects on public health from anticipated impacts of seismic surveys would occur primarily through impacts to subsistence. As discussed in section 4.4.1.3.17.5.6, subsistence forms the foundation of the diet, culture, social structure, and health of NSB residents. Interruptions in sharing networks could adversely impact social interconnectedness, a strong statistical predictor of both psychological and physical health (Marmot and Wilkinson, 2003). Stress and fear over potential or actual impacts to subsistence are an ongoing impact of OCS leasing, which could increase as seismic activities intensify, and are associated with psychological health problems such as depression, suicide, anxiety disorders, and drug and alcohol use. More dangerous subsistence conditions could lead to increased injury rates could f whales are displaced further from shore or become skittish and less predictable. Nutritional deficiencies could result if 1 or more subsistence resources were unavailable for longer than

one season. Food insecurity would likely increase in the event of a harvest failure of one or more major subsistence resource, and could increase even from proposals for seismic activity near a community's whaling grounds. The risk of chronic nutritionally-mediated diseases such as diabetes, high blood pressure, and heart disease, would increase proportional to the severity and duration of the impacts, with no sustained increase in prevalence of these disorders being anticipated unless subsistence harvest losses were sustained over time (i.e., a "major" subsistence impact). Alternative 1, the no-action alternative, would not contribute substantially to the cumulative effects on public health from seismic surveys.

#### 4.4.1.3.17.1.5 Anticipated Effects from Habitat Loss

The potential effects from habitat loss were discussed at section 4.4.1.3.17.5.

The cumulative effects to public health from habitat loss derive mainly from impacts to subsistence resources, harvests, and practices, which are discussed in Section 4.4.1.3.12.6.6. Onshore, construction of roads, pipelines, shorebases and CPFs could disrupt increasing areas of subsistence habitat. Health effects would include (1) Increased psychosocial problems such as stress and anxiety from more difficult and less successful subsistence hunts; (2) Increased injury rates from hunters having to travel longer distances to successfully harvest resources; (3) Increased food security from less reliable subsistence harvests; (4) Over time, if subsistence harvest impacts were sustained, increased risk of nutritional deficiencies and chronic diseases such as diabetes, high blood pressure, and cardiovascular disease. An additional concern would be stress and dysphoria caused by the proliferation of industrial infrastructure within view of communities, subsistence camps, and hunting routes. As noted by the NSB health director, Inupiat people are accustomed to am expansive, predominantly flat natural landscape with little interruption by vertical elements such as mountains, buildings (other than within villages), or other infrastructure (Habeich R, 2007, personal communication). The visuospacial changes created by pipelines, pads, rigs, and facilities associated with oil and gas development may have significant implications for people's relationship with the natural environment, sense of well-being, and psychological health. Alternative 1, the no-action alternative, would not contribute substantially to the cumulative effects on public health from habitat loss.

#### 4.4.1.3.17.1.6 Anticipated Effects from Economic, Employment, and Demographic Change

The potential public health effects from economic, employment, and demographic change were discussed at Section 4.4.1.3.17.5.8.

Socioeconomic status – as measured by income, education, and employment variables – is a powerfully associated with population health indicators such as life expectancy and overall mortality rates, and with rates of individual diseases including, for example, cardiovascular disease and cancer (Adler and Newman, 2002; Pamuk et al. 1998). The anticipated effects on economy and employment are discussed in section 4.4.2.11. Overall, revenues from onshore oil and gas production – the major source of income for the NSB – is projected to decline in coming decades. OCS activities could partially offset this decrease but are not expected to reverse it. Demographic changes, in terms of influx of direct and indirect workers, are shown in table 4.2.11-1 and 4.2.11-2.

The cumulative health effects associated with economic, employment, demographic would include the following. (1) Revenues from oil and gas activities presently fund the public health, water, and sanitation services offered by the NSB (as described in section 3.4.7). To the extent that revenues from OCS activities augment NSB revenue sources, they would help prevent the curtailment of current services, but would not be expected to provide additional revenue above current levels. (2) The influx of large number of non-resident workers from outside the area, particularly in the case of a shore base located near a village, or the staging of activities from a village, could result in increased social stress and tension, as described in section 4.4.1.3.13., and this could exacerbate psychosocial health issues such as substance abuse, depression and anxiety, violence, and suicide. (3) The influx of workers associated with oil and gas

activities has been associated with drug and alcohol problems in some studies, as discussed in Potential Effects above, and has been reported by residents of Nuiqsut. The influx of large number of non-resident workers could reduce the efficacy of local prohibition ordinances, leading to higher rates of drug and alcohol abuse and injuries. (4) The influx of non-resident workers could create an economic strain on NSB systems that protect health, including water and sanitation infrastructure, police staffing, EMS personnel, schools, roads and runways, and potentially others. (5) Employment and income generally support health – improving overall health outcome indicators and the rates of many specific diseases. The role of OCS-related income would best be viewed as contributing to slow the projected decline in revenues and employment related to oil and gas activities, as opposed to augmenting existing levels. (6) A large influx of workers from outside the region to or through NSB communities would create the risk of infectious disease transmission. This effect would be most prominent in cases where a major new facility such as a shore-base, or a new access route (such as an ice road or permanent road) led to sustained changes in the flow of people from outside the region through a village. Alternative 1, the no-action alternative, would not contribute substantially to the cumulative effects on public health from economic, employment, and demographic change. Relative to alternatives that involve OCS leasing, this alternative would offer the least revenue and employment.

### 4.4.1.3.17.1.7 Anticipated Effects from Production Activity

The potential effects from production activity are discussed in section 4.4.1.3.17.5.9.

The cumulative health effects from production activity would depend on (1) disruptions to subsistence resources, harvests, and practices; (2) influx of non-resident workers to and through communities; (3) the construction of new roads, pipelines, and facilities. Many of these effects have been discussed in sections 4.4.1.3.17.7.1-8. The assessment of cumulative effects on subsistence from production activity is limited by the absence of baseline data and consistent monitoring of past and present oil and gas production-related impacts (section 4.4.1.3.12.9.9). Alternative I, the no action alternative, would not contribute to production activity.

### 4.4.1.3.17.1.8 Anticipated Effects from Climate Change

The potential effects on public health from climate change were discussed in Section 4.4.1.3.17.5.19.

The cumulative effects of climate change on health are likely to be complex and cannot be estimated with certainty. Climate change is likely to influence the distribution and availability of subsistence resources, the stability of local housing and infrastructure, regional economy and demographics, and direct climate-related health effects. As stated by the U.S. Climate Change Science Program, Alaska communities will be particularly vulnerable to (1) extreme precipitation resulting in contaminated water and food supplies in areas with out-dated water treatment plants; (2) wildfires resulting in degraded air quality contributing to asthma and COPD; and (3) “fewer cold waves and higher minimum temperatures,” which could reduce cold-related injury (CCSP, 2008). The emergence of new infectious diseases is highly likely as warmer conditions allow vectors not seen in the Arctic to begin to survive there; early evidence of such changes has already been reported with the emergence of V. parahemolyticus as a pathogen in Alaska in 2004 (CCSP, 2008). Ozone depletion – the result of pollution and warming – is increasing in the Arctic and may lead to increases in UV related problems such as skin cancers.

Many changes are already being observed. Thinner ice has made conditions more difficult for spring whaling crews to land successfully harvested whales; unpredictable ice conditions and late freezups have made it more difficult and dangerous for hunters to harvest and travel in the early season on land. According to the IPCC, these changes are likely to accelerate in coming decades (IPCC, 2007).

One of the most concerning implications for climate change is the recognition that coastal communities and low income communities will likely be disproportionately impacted. The remoteness and limited

sources of income in NSB communities may limit the ability to adapt and respond to the major challenges posed by accelerated erosion and infrastructure problems that are already beginning to be seen in Alaska (ACIA, 2004). As these stresses accumulate, it will become more difficult for communities to respond to other challenges such as more difficult subsistence harvest conditions, creating the risk that health disparities will be exacerbated. Alternative 2, the no action alternative, would not contribute to the cumulative effects from climate change.

#### 4.4.1.3.17.2 Direct and Indirect Impacts from Selecting Alternative 2 (No Lease Sale)

There would be no direct or indirect impacts to public health from selecting Alternative 1.

### 4.4.2. Beaufort Sea Alternative 2, Proposed Action

Alternative II, the Proposal for Sales 209 and 217, offers for lease the entire area outlined in Map 1. This alternative encompasses 6,123 whole or partial blocks that cover 33, 194,467 million acres (about 13,426,469 million hectares). This area minus leased blocks would be offered in both sales.

#### 4.4.2.17.1 Anticipated Effects on Public Health

Public Health in the Beaufort Sea Planning Area is subject to the same potential effects described previously in section 4.4.1.3.17.1-10, and the same cumulative past, present, and reasonably foreseeable actions described in sections 4.4.1.17.7.1-10. This section describes the impact on public health from the incremental impact of this action – the Proposed Action alternative – and adding it to other past, present, and reasonably foreseeable future actions regardless of what agency or entity undertakes such actions. Reasonably foreseeable future actions are described in Section 4.2. Mitigation measures are described in Section 4.4.1.12.17, and the implications of existing mitigation measures on public health are described in Section 4.4.1.3.17.6. New potential mitigation measures to address public health issues from OCS development are presented and discussed in section 4.4.1.3.17.6.2. Their efficacy is analyzed as part of the anticipated effects.

#### 4.4.2.17.1.1 Anticipated Effects from Disturbance

Oil and gas exploration and development in the Beaufort Sea Planning Area could result in disturbance to marine mammal resources and harvests. It is hoped that mitigation measures imposed by MMS on future exploration and development activities would minimize adverse effects to these resources. Vessel and aircraft disturbance associated with the proposed action are anticipated to have a minor effect on marine mammal resources and subsistence harvests in the Beaufort Sea Planning Area.

Public health impacts related to disturbance would occur in proportion to the interruption or interference with subsistence activities. General Health and Well-being and Psychosocial problems could be affected if disturbances resulted in hunting or whaling failures. More difficult subsistence conditions or failed hunts could lead to stress and maladaptive coping strategies (increased alcohol or drug use, domestic violence). If whales were displaced or made more skittish by aircraft and vessel disturbances, injuries could result. Similarly, on land, caribou displacement or behavioral changes in response to vessel or aircraft disturbances could lead to the need to travel greater distances to harvest caribou. Snow machine accidents have been shown to occur in proportion to the miles travelled, so this could increase the risk of accidents for hunters on land (Landen et al., 1999). Because it is anticipated that displacement would not be severe enough to render resources unavailable to hunters (see section 4.4.1.3.12.6.1), it is possible but unlikely that vessel and aircraft disturbance effects on nutrition, diet, and related health problems would occur. Overall, because the effects of disturbance on subsistence harvests is projected to be minor, health effects from disturbance are likely to be negligible. The exception would be if isolated injuries occurred

secondary to whales becoming more aggressive or being displaced into rougher waters. Injuries related to displacement of whales would constitute a moderate to major impact.

**Mitigation.** Mitigation measures such as the AAMP and IHA agreements, if implemented effectively, would be expected to minimize the chance of injuries occurring. Section 4.4.1.3.17.6.2 discusses potential new mitigation measures to address newly identified health risks. Potential Mitigation Measure 1 would ensure that major OCS projects addressed potential health effects and developed mitigation plans. Potential Mitigation Measures 2 and 3 would ensure an adequate database and ongoing monitoring of public health measures, which would allow the assessment of both disturbance-related health effects and of the efficacy of mitigation measures developed to protect health.

#### 4.4.2.17.1.2 Anticipated Effects from Discharges

Current water quality in the Arctic OCS is relatively pristine, and present industrial impacts are minimal. The potential effects on public health from discharges are described in section 4.4.1.3.17.5.2. Exposure to discharges could occur directly (through contact with contaminated water), or through contact with contaminated subsistence resources. As noted in section 4.4.1.3.17.5.2, concern about contaminants is a powerful determinant of people's confidence in and use of subsistence resources.

The USEPA NPDES General Permit issued for activities in Arctic waters is designed to establish discharge limits that protect human health. However, as described in section 4.4.1.3.17.5.2, there are legitimate scientific questions that can be posed regarding the certainty of assumptions used to set acceptable levels of pollution. Because of the high importance of the OCS environment to the subsistence practices, health and well-being of local communities, the NSB undertook a review of the available literature used in reaching this conclusion, and notes that there are a number of assumptions and uncertainties on which this conclusion is based. First, it must be noted that metals including mercury can be found not only in drilling muds but in cuttings as well. Thus, the elevated metal concentrations sometimes seen in cuttings piles may be from a combination of cuttings, accumulation and migration from the natural sediment, from discharges of barite, from specialty chemicals in drilling muds, from the platform itself (i.e., paint chips, corrosion) and from aeolian input. The introduction of oxygen, the amount an types of specialty chemicals, and the oil content of the cuttings are all variables which influence the kinetics, chemistry, and time frame associated with the sorption (binding) and desorption (release) of metals bound up in the cuttings piles. Additionally, disruption of tailing piles may release large concentrations of metals as a result of oxidation of metal sulfide complexes. No field work has demonstrated that the metals found in cuttings piles are likely to remain in a "bound" (and therefore less bioavailable) form (Rosa C, personal communication by email, 2008.) Another potential concern for human health associated with OCS discharges is "naturally-occurring radioactive material" (NORM), which is present in the shales from which oil and gas are extracted. During extraction, reactions can occur which result in dissolved radionuclides remaining in solution in the drilling fluids or precipitating and becoming incorporated into the solid components of drill cuttings. This process depends on water chemistry, temperature, and pressure. Chronic exposure to radiation may result in mortality, mutagenesis, or decreased fertility or sterility for exposed organisms (Holdway, 2002). A final data gap that limits the ability to accurately predict potential health effects from discharges is the lack of quantitative nutritional data, which would be necessary to accurately model the potential exposure of subsistence users to contaminants from OCS discharges. Given these limitations, for widely interspersed exploratory drilling, it may be reasonable to conclude that the risks are relatively low; on the other hand, as activities in the planning area and adjacent OCS areas intensify, the accumulation of contaminants in the Arctic OCS ecosystem could become a more substantial concern.

Contamination of subsistence resources through bioaccumulation, depending upon the specific pollutant, would pose a risk of cancer, teratogenesis, or neurodevelopmental delay. Community concern over potential contamination from activities under this alternative, coupled with acknowledged data gaps,

could influence fears that contaminants from OCS activities may impact subsistence resources, and could be a substantial source of stress in impacted communities. Contamination and the perception of contamination of subsistence resources may also affect the use of subsistence foods through reduced or abandoned harvests, increased stress about the effects of consuming possibly tainted food, concerns about future availability of subsistence resources, and a decline in the satisfaction of eating subsistence food sources; fears regarding contamination have been shown to influence consumption of subsistence resources (Ballew et al., 2004; Poppel et al., 2007). Reduced consumption of subsistence foods would increase the risk of food insecurity, nutritional deficiencies, and chronic diseases such as diabetes, high blood pressure, and cardiovascular disease.

**Mitigation.** The newly adopted BLM ROP A-11 would reduce concerns about contaminants from onshore oil and gas operations, through assuring adequate baseline data on current contaminant levels, and through monitoring contaminants produced from onshore operations in subsistence resources; this measure provides for BLM intervention if levels of contaminants reach levels that could pose a risk to the human population. Section 4.4.1.3.17.6.2 describes new potential mitigation measures for public health. Section 4.4.1.3.17.6.2 discusses potential new mitigation measures to address newly identified health risks. Potential measure 6, OCS Discharges and Health, would create a monitoring and discharge control framework specifically tailored to address the fate and accumulation of contaminants given the unique ecosystem of the Arctic OCS environment, and the extraordinarily high consumption of animal tissues among subsistence users. MMS Potential Mitigation Measure 1 would ensure that major OCS projects addressed potential health effects and developed mitigation plans. Potential Mitigation Measures 2 and 3 would ensure an adequate database and ongoing monitoring of public health measures, which would allow the assessment of both discharge-related health effects and of the efficacy of mitigation measures developed to protect health.

### 4.4.2.17.1.3 Anticipated Effects from Large Oil Spills

Public health in the Beaufort Sea Planning Area is subject to the same potential effects from large oil spills described in Section 4.4.1.3.17.5.3, and the same anticipated and cumulative past, present, and reasonably foreseeable future actions previously described in section 4.4.1.3.17.7.3. The anticipated public health effects from a large spill under this alternative would be the same as these effects, if a spill actually occurred. Section 4.4.2.3.17 presents the results of the OSRA for this alternative. The large oil spill occurrence estimate is based on the estimated volume of oil produced. The NSB has pointed out that the OSRA would be strongly impacted by oil prices, in that a high level of industrial activity (and therefore a higher risk of spills) would be predicted if oil prices are higher.

In the absence of an actual spill, it must be acknowledged that the fear of a large spill creates significant health effects. Stress created by the fear of an oil spill is a distinct impact-producing agent within the human environment. Stress from this general fear can be broken down to the specific fears of:

- being inundated during cleanup with outsiders who could disrupt local cultural continuity;
- the damage that spills would do to the present and future natural environment;
- drawn out oil-spill litigation;
- contamination of subsistence foods;
- the lack of local resources to mobilize for advocacy and activism with regional, State, and Federal agencies;
- the lack of personal and professional time to interact with regional, State, and Federal agencies;
- retracing the steps (and the frustrations involved) taken to oppose offshore development;
- responding repeatedly to questions and information requests posed by researchers and regional, State, and Federal outreach staff; and
- the need to employ and work with lawyers in drafting litigation to attempt to stop proposed development (USDOI, MMS, 2003a; USDOI, BLM and MMS, 2003).

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The impacts of recently increased interest in OCS leasing, such as the unanticipatedly high bidding for tracts in OCS Lease Sale 193, coupled with Shell's submission of an exploration permit application, have intensified fears in local communities, where residents must face the very real possibility that an era of active OCS exploration and development is beginning. Stress and anxiety are health effects in their own right, and can contribute as well to other problems such as psychosocial health problems (violence, drug and alcohol abuse, suicide), as well as physical health problems for which stress is a well-documented risk factor, such as cardiovascular disease and exacerbations of asthma. These problems would be particularly likely in individual communities near a major exploration or development project.

**Mitigation.** Section 4.4.1.3.17.6.2 discusses potential new mitigation measures to address newly identified health risks. Potential new mitigation measures for public health are discussed in section 4.4.1.3.17.6.2. Mitigation would not be expected to prevent or eliminate adverse health effects from a large spill, but would be a critically important part of an adequate response. Potential mitigation measure 3, public health monitoring, would create a mechanism through which the public health effects of a large spill could be tracked, which would facilitate an adequate response from the public health and health care systems. Potential mitigation measure 4 would track nutritional impacts from a large oil spill, and requirements for measures that would help protect the nutritional health of residents.

### 4.4.2.17.1.4 Anticipated Effects from Oil-Spill Response and Cleanup

Public health in the Beaufort Sea Planning Area is subject to the same potential effects from large oil spills described in Section 4.4.1.3.17.5.4, and the same anticipated and cumulative past, present, and reasonably foreseeable future actions previously described in section 4.4.1.3.17.7.4. The anticipated public health effects from a large spill under this alternative would be the same as the potential effects, if a spill actually occurred. Section 4.4.2.3.17 presents the results of the OSRA for this alternative. The influx of personnel, and sudden employment and income increase for some local residents could impact public health. A large, uncontrolled influx of non-resident cleanup personnel to or through villages would increase the change of infectious disease transmission; the rapid increase in income coupled with subsistence impacts and the potential that alcohol or illicit drugs might be brought into the region by transient cleanup personnel creates a risk for increased alcohol and substance abuse. Hunters now providing subsistence foods for the community might spend less time hunting if employed in cleanup, which would create nutritional impacts on the community.

**Mitigation.** Section 4.4.1.3.17.6.2 discusses potential new mitigation measures to address newly identified health risks. Potential new mitigation measures for public health are discussed in section 4.4.1.3.17.6.2. Potential mitigation measure 3, public health monitoring, would augment existing public health monitoring programs and create a mechanism through which the public health effects of a large spill could be tracked, which would facilitate an adequate response from the public health and health care systems. Potential measure 7 would ensure some orientation to the issues of drug and alcohol problems and sexually transmitted diseases, and could help prevent these problems during oil spill response. Measure 8, the socioeconomic monitoring and mitigation plan, would ensure that the NSB could recover the service and infrastructure costs associated with hosting a large oil spill response, such as increased policing in communities through which non-resident workers enter the area, and increased wear and tear on roads and runways.

### 4.4.2.17.1.5 Anticipated Effects from Airborne Emissions

Public health in the Beaufort Sea Planning Area is subject to the same potential effects from airborne emissions as those described in Section 4.4.1.3.17.5.5, and the same cumulative past, present, and reasonably foreseeable actions previously described in Section 4.4.1.17.7.5. As noted by the ADEC, however, "transport and deposition of pollution downstream of the North Slope facilities may be having a

noticeable effect on the environment of the NPR-A. Currently, no data has been collected to document if the substantial amount of pollution emitted on the North Slope, although not in violation of air standards, may be having a significant cumulative effect on this area" (ADNR 2007). The same gaps in baseline data apply to the Beaufort OCS, particularly west of the Alpine oilfield, the farthest west air quality monitoring site currently on the North Slope. Monitoring data are therefore not sufficient to allow determination of the contribution of current oilfield emissions to air quality in Barrow or other villages remote from Prudhoe Bay, relative to the contributions of other known sources in Northern Europe and Asia. Because of the distances from the most likely developments to Beaufort coastal communities and the relatively small sizes of anticipated development in the Beaufort compared to the Prudhoe Bay complex, however, the proposed sale should have little to no significant effect on the air quality of coastal communities.

Airborne emissions from OCS activities pose two potential concerns. Subsistence users could be impacted if whaling or other hunting activities are occurring near or downwind from OCS facilities. Emissions from these facilities could cause exacerbations of chronic lung disease or asthma, and cardiovascular events (heart attacks, arrhythmias). Given the size of the Planning Area relative to areas frequented by hunters, it is anticipated that such events would be rare. Secondly, HAP emissions could contact subsistence users in the area, and others (particularly PAH) could be deposited in the aquatic environment and could accumulate in subsistence species. Overall, effects from airborne emissions would be moderate, although if exposure to contaminants resulted in a problem such as cancer or heart attack in an individual, this would be considered a major effect.

**Mitigation**. Section 4.4.1.3.17.6.2 discusses potential new mitigation measures to address newly identified health risks. The newly adopted BLM measure ROP A-10 would ensure adequate evaluation and monitoring of air pollution from onshore facilities, and provide a mechanism for adaptive management if oil and gas operations were found to be contributing to the risk for adverse health outcomes. MMS Potential Mitigation Measure 5, Air Quality and Health, would institute similar requirements for OCS lessees. MMS Potential Mitigation Measure 1 would ensure that major OCS projects addressed potential health effects and developed mitigation plans. Potential Mitigation Measures 2 and 3 would ensure an adequate database and ongoing monitoring of public health measures, which would allow the assessment of both discharge-related health effects and of the efficacy of mitigation measures developed to protect health.

### 4.4.2.17.1.6 Anticipated Effects from Seismic Surveys

Public health in the Beaufort Sea Planning Area is subject to the same potential effects from airborne emissions as those described in Section 4.4.1.3.17.5.6, and the same cumulative past, present, and reasonably foreseeable actions previously described in Section 4.4.1.17.7.6. Given the level of potential seismic-survey activity described in the scenario—up to three concurrent seismic surveys seasonally in the Beaufort Sea—and past assessments of species and resource effects discussed above, whales, pinnipeds, and polar bears might be displaced and their availability affected for an entire harvest season, potentially causing major impacts. Protective mitigation measures incorporated into seismic-survey permits, required industry Adaptive Management Mitigation Plans (AMMPs), and required mitigation under IHA requirements, as defined by NMFS and FWS is expected to reduce noise disturbance impacts (PEA), so that no unmitigable adverse effects to subsistence resources and harvest practices occur. However, as pointed out by the NSB at the Open Water meetings in 2008, the current and projected increases in seismic exploration activity in the Beaufort has already begun to overwhelm agency capacity to monitor impacts and industry and agency ability to coordinate efforts with whalers. Hence, it cannot be stated with certainty that present mitigation will prove effective.

Adverse health effects from seismic surveys would relate to impacts to subsistence resources and harvests. As described in Section 3.4.7 and Alternative 1, public health and well-being in the NSB

depend to a large extent upon subsistence resources. Disruption of subsistence harvests of whales, belugas, and pinnipeds, and polar bears by seismic activity could disrupt the central Inupiat cultural value (subsistence), the foundation of the North Slope nutritional system, and sharing networks, and would thereby adversely affect indicators of general health and wellbeing and could adversely impact the rates of psychosocial problems such as family violence, drug and alcohol problems, depression, anxiety, and suicide. Displacement of whales from their normal migration routes could increase the risk involved in hunting them, increasing the risk of accidents and injuries. Unpredictable behavior of whales disturbed by seismic activity would compound this risk. Displacement of whales could also result in longer towing times increasing the risk of spoilage. Food insecurity would thus likely increase as a result of harvest failures, and the severity of this problem would be proportional to the number and extent of failures and to the effects on extended sharing networks that reach outside the affected community. Store-bought foods would not be expected to provide adequate replacement micronutrients, and micronutrient deficiencies and anemia could result. If it became necessary to replace subsistence calories with store-bought foods, this would incrementally increase the risk of metabolic syndrome disorders including diabetes, hyperlipidemia, and high blood pressure, with the severity of this problem correlating with the severity and frequency of impacts to subsistence. These effects would be most prominent in Nuiqsut, where impacts from onshore development have resulted in some restriction of the traditional subsistence range on land (USDOI BLM 2008), but other coastal villages in the planning area could also be affected. The Proposed Action could intensify these effects through making a larger area available for seismic exploration, which could occur in and near key OCS subsistence areas. If harvest disruptions were infrequent, intermittent events effects would be moderate; if they became more common or occurred over consecutive seasons, health effects would be major.

**Mitigation.** Section 4.4.1.3.17.6.2 discusses potential new mitigation measures to address newly identified health risks. Potential mitigation measure 1 would ensure that any major exploration or development proposal in the region analyzed and mitigated potential health impacts. Potential mitigation measure 2 would provide baseline information on health and drivers of health in communities affected by OCS activities, and would enable more accurate assessment of the impacts of OCS activities on health and would form the foundation of a monitoring strategy that would allow adaptation of MMS' management strategies and the public health system based on observed changes in health. Potential measure 3 would augment the existing public health monitoring programs and establish a system through which health problems related to OCS development could be monitored. Potential mitigation measure 4 would not completely offset the loss of subsistence resources if they occurred, but would provide a safety net that would help ensure an adequate supply of wild-harvested foods, and the institution of public health programs that would attempt to offset the incremental increased risk of diabetes and related metabolic disorders that would accrue from adverse impacts to subsistence harvests. Potential mitigation measure 8 would provide a mechanism through which the NSB could potentially track and recoup economic losses related to subsistence impacts.

### 4.4.2.17.1.7 Anticipated Effects from Habitat Loss

Public health in the Beaufort Sea Planning Area is subject to the same potential effects from habitat loss as those described in Section 4.4.1.3.17.5.7, and the same cumulative past, present, and reasonably foreseeable actions previously described in Section 4.4.1.17.7.7. Permanent habitat loss would only arise from the construction of development and productions facilities (an offshore platform, undersea pipeline, pipeline landfall to an onshore base, and onshore, a shorebase/processing facility and a pipeline linking to existing infrastructure). The public health effects of habitat loss would be expected to mirror impacts to subsistence resources: the health implications of such impacts are described in detail in section 4.4.1.3.17.5.6. An additional concern would be stress and dysphoria caused by the proliferation of industrial infrastructure within view of communities, subsistence camps, and hunting routes. As noted by the NSB health director, Inupiat people are accustomed to am expansive, predominantly flat natural landscape with little interruption by vertical elements such as mountains, buildings (other than within

villages), or other infrastructure (Habeich 2007, personal communication). The visuospacial changes created by pipelines, pads, rigs, and facilities associated with oil and gas development may have significant implications for people's relationship with the natural environment, sense of well-being, and psychological health.

#### 4.4.2.17.1.8 Anticipated Effects from Economic, Employment, and Demographic Change

Public health in the Beaufort Sea Planning Area is subject to the same potential effects from economic, employment, and demographic change as those described in Section 4.4.1.3.17.5.8, and the same cumulative past, present, and reasonably foreseeable actions previously described in Section 4.4.1.17.7.8. Economic effects could come from a combination of revenues to the NSB from taxation of onshore infrastructure; the CIAP; employment (direct and indirect) for residents; Native Corporation revenues from business and land-use agreements; inflation for goods and services in villages that experience significant flow of non-resident workers through the community; and increased demands on services and wear and tear on infrastructure. Demographic change would come from a combination of influx of non-resident workers and emigration and immigration secondary to employment and economic opportunities. The economic analysis in section 4.4.2.11 predicts relatively small overall impacts on economy and employment. Indirect and direct employment figures are given in tables 4.4.2.11-1 and 4.4.2.11-2.

Overall, the economic effects of the lease sale could serve to slow the predicted rate of economic contraction in the region related to decreasing production from onshore facilities. This would have benefits for water and sanitation and public health services administered by the NSB. Employment has mixed effects on subsistence: as described in detail in section 4.4.1.3.17.5.8, income from employment can provide income for fuel and equipment, but hunters employed in resource development work outside of the community may spend less time hunting. The influx of large number of non-resident workers from outside the area, particularly in the case of a shore base located near a village, or the staging of activities from a village, could result in increased social stress and tension, as described in section 4.4.1.3.13., and this could exacerbate psychosocial health issues such as substance abuse, depression and anxiety, violence, and suicide. The influx of workers associated with oil and gas activities has been associated with drug and alcohol problems in some studies, as discussed in section 4.4.1.3.17.5.9, and has been reported by residents of Nuiqsut. The influx of large number of non-resident workers could also reduce the efficacy of local prohibition ordinances, leading to higher rates of drug and alcohol abuse and injuries. Finally, the influx of non-resident workers could create an economic strain on NSB systems that protect health, including water and sanitation infrastructure, police staffing, EMS personnel, schools, roads and runways, and potentially others. Overall, the economic, employment, and demographic effects associated with the Proposed Action be major.

**Mitigation.** Section 4.4.1.3.17.6.2 discusses potential new mitigation measures to address newly identified health risks. Potential new mitigation measure 8 could provide a means through which the "hidden" economic costs of hosting OCS activities could be recouped by the NSB, which would effectively offset the excess demands on public services and infrastructure. These funds could allow for the hiring of additional public safety or EMS personnel, and repair and maintenance of infrastructure that would support health. Potential mitigation measure 9 would create a process through which the NSB and affected communities would evaluate proposals for onshore facilities supporting OCS development, and to develop a health-focused, balanced plan, which would maximize potential benefits for communities and minimize unintended adverse effects. MMS Potential Mitigation Measure 1 would ensure that major OCS projects addressed potential health effects and developed mitigation plans. Potential Mitigation Measures 2 and 3 would ensure an adequate database and ongoing monitoring of public health measures, which would allow the assessment of both health effects related to economy, employment, and demographics, and of the efficacy of mitigation measures developed to protect health. Collectively, these measures could reduce the adverse health effects related to economic, demographic, and employment

change from the Proposed Alternative substantially, but would not be expected to eliminate them, as influx would still occur.

### 4.4.2.17.1.9 Anticipated Effects from Climate Change

Public health in the Beaufort Sea Planning Area is subject to the same potential effects from climate change as those described in Section 4.4.1.3.17.5.10, and the same cumulative past, present, and reasonably foreseeable actions previously described in Section 4.4.1.17.7.10. The cumulative effects of climate change on health are likely to be complex and cannot be estimated with certainty. Climate change is likely to influence the distribution and availability of subsistence resources, the stability of local housing and infrastructure, regional economy and demographics, and direct climate-related health effects. As stated by the U.S. Climate Change Science Program, Alaska communities will be particularly vulnerable to (1) extreme precipitation resulting in contaminated water and food supplies in areas with out-dated water treatment plants; (2) wildfires resulting in degraded air quality contributing to asthma and COPD; and (3) "fewer cold waves and higher minimum temperatures," which could reduce cold-related injury (CCSP, 2008). The emergence of new infectious diseases is highly likely as warmer conditions allow vectors not seen in the Arctic to begin to survive there; early evidence of such changes has already been reported with the emergence of V. parahemolyticus as a pathogen in Alaska in 2004 (CCSP, 2008). Ozone depletion – the result of pollution and warming – is increasing in the Arctic and may lead to increases in UV related problems such as skin cancers.

Many changes are already being observed. Thinner ice has made conditions more difficult for spring whaling crews to land successfully harvested whales; unpredictable ice conditions and late freezups have made it more difficult and dangerous for hunters to harvest and travel in the early season on land. According to the IPCC, these changes are likely to accelerate in coming decades (IPCC, 2007).

One of the most concerning implications for climate change is the recognition that coastal communities and low income communities will likely be disproportionately impacted. The remoteness and limited sources of income in NSB communities may limit the ability to adapt and respond to the major challenges posed by accelerated erosion and infrastructure problems that are already beginning to be seen in Alaska (ACIA, 2004). As these stresses accumulate, it will become more difficult for communities to respond to other challenges such as more difficult subsistence harvest conditions, creating the risk that health disparities will be exacerbated. The Proposed Alternative could compound the public health effects of climate change through exacerbating the speed and degree of change in the availability and distribution of subsistence resources. Furthermore, OCS oil and gas development would contribute incrementally to climate change, and therefore to climate change-related health effects in the NSB. Incremental contributions to climate change would include GHG emissions from equipment and facilities involved in exploration and production, and combustion of oil and gas produced from OCS development. Current climate change and health models are not precise enough to allow quantification of the contribution of OCS development to climate change-related health impacts. The analysis of the contribution of individual projects and policies to GHG-related effects is a matter of current discussion within federal agencies, and there is little consensus. The IPCC uses 6 well-defined and tested human development scenarios to model climate impacts. High fossil fuel use scenarios – the "A1Fl scenario" in which current trends of increasing use of fossil fuels continue – are associated with the highest risks to human health (IPCC 2008). To the extent that OCS leasing programs are one component of a U.S. energy policy that continues to rely heavily on fossil fuel production, and to the extent that OCS activities facilitate this policy, the Arctic Multisale program would fall into the A1Fl category of emissions, and therefore pose the greatest risk to human health compared with other GHG emissions scenarios. On the other hand, OCS activities would help stabilize declining revenues and employment in the NSB, which would generate health benefits as discussed above.

**Mitigation.** MMS Potential Mitigation Measure 1 would ensure that major OCS projects addressed potential health effects and developed mitigation plans. Potential Mitigation Measures 2 and 3 would ensure an adequate database and ongoing monitoring of public health measures, which would allow the assessment of both health effects related to economy, employment, and demographics, and of the efficacy

of mitigation measures developed to protect health. MMS Potential Mitigation Measure 10, Climate Change, OCS Activities, and Subsistence, would help communities adapt to the cumulative stresses of climate change and OCS activities on subsistence and nutrition, but would certainly not eliminate the concerns described above.

### 4.4.2.17.2 Direct and Indirect Impacts from Selecting Alternative 2

**Summary.** The following analysis describes only the anticipated direct and indirect effects on public health if the MMS opens the entire Beaufort Sea lease sale area with no deferrals, in isolation from other actions possible in the cumulative scenario, as required by NEPA. Current thought in public health has suggested that descriptors such as "direct and indirect" may be misleading, because they can be seen as implying a causal linkage that is "indirect" is less robust or important as a determining factor for health status; these terms thus risk misplacing emphasis on causal relationships that appear more "direct," when the more powerful epidemiologic associations may be on risk factors that are less direct (Krieger, 2008). Statistically robust modern public health data have demonstrated that social, economic, and environmental conditions explain well over 50% of the difference in health status between subgroups in a society, and are therefore among the most important causal association for the field of public health (Marmot and Wilkinson, 2003; Lantz et al., 2003; Pamuk et al., 1998).

Direct effects to public health could occur from exposure to contaminants through discharges, emissions, or oil spills during exploration, development, or production. A large oil spill contacting subsistence resources is possible in this scenario, but statistically fairly unlikely based on the OSRA for this alternative. Noise associated with disturbance from increased air traffic could disrupt community well-being. Influx of non-resident workers (detailed in section 4.4.2.11 and subsections) could lead to decreased community cohesion. Projects in the Planning Area would operate under NPDES and NAAQS standards, which are promulgated to protect health. Furthermore, most major emissions sources under this alternative would be located far from communities, either offshore or using existing industrial infrastructure onshore. Nevertheless, vulnerable groups (elders, young children, and people with chronic illnesses) may suffer adverse outcomes at levels of pollution substantially below these standards. The most likely scenario would be intermittent exposure from hunting activities, and possibly lower-level exposure under specific climate conditions.

The entire Planning Area would be open to leasing without deferrals under this alternative, raising the chance that subsistence resources, harvests, or practices could be disrupted; disturbance from aircraft and vessels would be a factor throughout the life of the sale; up to 3 concurrent seismic operations would be permitted in the Beaufort Sea under this alternative; production platforms and activity, and onshore operations to support OCS development and production, if it occurred, could also displace subsistence resources. Subsistence impacts are associated with the following health effects: (1) Undermine the protective aspects of the culture and social structure provided by subsistence, incrementally contributing to already elevated rates of social and psychological health problems. (2) Food security could increase even with a major exploration proposal or with actual subsistence impacts. (3) If harvest of one or more resources were restricted for more than one season, nutritional deficiencies could result. (4) Increased accidents and injuries if subsistence hunters had to travel longer distances to contact resources, or if whales exhibited less predictable or more agitated behavior because of disturbances from activities under this alternative.

Influx of non-resident workers under this alternative (shown in table 4.4.2.11-1 and 4.4.2.11-2) could intensify cultural conflict and could undermine community cohesion, increasing the risk of psychosocial problems. Influx would also potentially be associated with the possibility of drug and alcohol importation, and this would be compounded by the need for additional police staff to adequately handle

the flow of non-residents through the villages. Influx of non-resident workers from outside the region also poses the risk of infectious disease transmission between low and high prevalence groups.

The modest economic and employment effects predicted in section 4.4.2.11 would tend to stabilize the NSB economy, but may not offset gradual declines in revenues and employment from onshore oil and gas activity. Economy and employment are generally associated with improved overall health and less psychosocial strain. Economic inputs would also help prevent deterioration of water and sanitation infrastructure, and could stabilize health and other services provided by the NSB.

The AMMP and IHA could reduce the risk of deflecting subsistence resources, but their efficacy has not been tested under conditions of multiple, concurrent activities in the region. The potential mitigation measures for public health presented in section 4.4.1.3.17.6.2 could further reduce the likelihood of adverse health effects as discussed in 4.4.2.17.3.

### 4.4.3.17.1 Beaufort Sea Alternative 3, Barrow Deferral

This alternative was developed by MMS in response to scoping comments received in Barrow. This deferral would reduce potential conflicts between bowhead whale subsistence hunters and offshore oil and gas operations, based on bowhead whale-strike data provided by the Alaska Eskimo Whaling Commission (AEWC), increasing protection to the Barrow subsistence whale hunt and other subsistence activities from potential noise and disturbance from exploration or development and production activities. This alternative would offer for leasing all of the area described for Alternative 2 except for a subarea located in the western portion of the proposed sale area. Alternative 3 would offer 6,108 whole or partial blocks, comprising 33,126,710 million acres (about 13.4 million hectares). The area removed by the Barrow Subsistence Whale Deferral consists of 15 whole or partial blocks, approximately 67,757 acres (27,400 hectares), approximately .2% of the proposed sale area. The majority of the bowhead whale subsistence-hunting area near Barrow includes an area in the Chukchi Sea, which was already removed from leasing in the 2007-2012 5-Year Program. The alternative is intended to reduce effects on subsistence harvest patterns because no exploration or production activities would occur in the deferral area.

### 4.4.3.17.2 Direct and Indirect Effects of Selecting Alternative 3 on Public Health

This deferral would prohibit leasing, exploration, development, and production activities; thus, moving the zone for potential noise, disturbance, discharges, airborne emissions, and oil-spill effects farther away from subsistence whaling areas. Climate change, and economic, employment and demographic effects would be similar between this Alternative and Alternative 3. By reducing potential subsistence impacts, this Alternative would reduce anticipated public health impacts relative to Alternative 3; this difference would be most evident in Barrow, but would also be important in villages that receive shared subsistence resources from Barrow. As described in section 4.4.1.3.17 and subsections (Beaufort Sea Alternative 1, public health), subsistence forms the foundation of health in rural Alaska Native villages. Adverse effects on subsistence can impact general health and wellbeing, diet and nutrition, injury rates, and rates of nutrition-related chronic diseases such as diabetes, hypertension, and cardiovascular disease.

### 4.4.3.17.3 Cumulative Effects of Selecting Alternative 3

This alternative would reduce subsistence and subsistence-related health impacts for Barrow and villages with which Barrow shares subsistence resources.

#### 4.4.4.17.1 Beaufort Sea Alternative 4, Cross Island Deferral

This alternative would offer for leasing all of the area described for Alternative 2, except for a subarea located near Cross Island. Alternative 4 would offer 6,082 whole or partial blocks, comprising 32,986,825 million acres (about 13.4 million hectares). The area that would be removed by the Cross Island Deferral consists of 41 whole or partial blocks. This alternative addresses issues of protecting harvest areas important to the Nuiqsut subsistence bowhead whale hunt as identified by the AEWC, the Native Village of Nuiqsut, and the North Slope Borough (NSB).

#### 4.4.4.17.2 Direct and Indirect Effects of Selecting Alternative 4 on Public Health

This deferral would prohibit leasing, exploration, development, and production activities on deferred blocks; thus, moving the zone for potential noise, disturbance, discharges, airborne emissions, and oil-spill effects farther away from subsistence whaling areas. Climate change, and economic, employment and demographic effects would be similar between this Alternative and Alternative 4. By reducing potential subsistence impacts, this Alternative would reduce anticipated public health impacts relative to Alternative 3; this difference would be most evident in Nuiqsut, but would also be important in villages that receive shared subsistence resources from Nuiqsut. As described in section 4.4.1.3.17 and subsections (Beaufort Sea Alternative 1, public health), subsistence forms the foundation of health in rural Alaska Native villages. Adverse effects on subsistence can impact general health and wellbeing, diet and nutrition, injury rates, and rates of nutrition-related chronic diseases such as diabetes, hypertension, and cardiovascular disease.

#### 4.4.4.17.3 Cumulative Effects of Selecting Alternative 4

Nuiqsut has experienced cumulative impacts from past and present oil and gas exploration. Effects on subsistence harvest and use, and any associated stress to community social organization, are most likely to occur onshore in the community of Nuiqsut because of its proximity to oil-patch infrastructure at Alpine and Prudhoe Bay. Development is being considered for the Northeast NPR-A corner of the planning area for Alpine Field Satellites development, and further exploration and delineation activity is ongoing in the leased areas south of Teshekpuk Lake. If oil and gas activities were to continue in areas already leased, Nuiqsut residents would be increasingly isolated from their subsistence resources and would be encircled by development. While community members of Barrow and Atqasuk all pursue subsistence activities in this area, they take a larger proportion of their subsistence harvest from other areas not directly affected and thus are less likely to experience subsistence-related disruption to their social organization. In the past, non-Native workers have stayed in enclaves that kept interactions down. However, recent activity in the Alpine field has brought non-Natives directly into the Native village of Nuiqsut, and this has added stresses in the community. These workers already have made demands on the village for more electrical power and health care. This potential remains for the community of Barrow and Atqasuk as well (USDOI, BLM and MMS, 2003). OCS activities near Cross Island could add to these cumulative burdens, through impacts to Nuiqsut's whaling and through the possible increased influx of non-resident workers to and through the village, and therefore reduce the risk of adverse effects on general health and wellbeing, diet and nutrition, injury rates, and rates of nutrition-related chronic diseases such as diabetes, hypertension, and cardiovascular disease. However, because MMS is not considering the deferral of a larger region around and to the East of Cross Island recommended by Nuiqsut whalers (see Section 2.1.1.7), impacts to the Cross Island whale subsistence hunt could still occur.

#### 4.4.5.17.1 Beaufort Sea Alternative 5, Eastern Deferral

This alternative would defer 80 whole or partial blocks east of Kaktovik. This deferral was developed to protect bowhead whale habitat and to buffer potential impacts to Kaktovik subsistence whaling areas, as

requested by the Native Village of Kaktovik and the AEWC. This area adjoins an area that the State of Alaska has deferred in recent State lease sales.

#### 4.4.5.17.2 Direct and Indirect Effects of Selecting Alternative 5 on Public Health

This deferral would prohibit leasing, exploration, development, and production activities in the deferred area, thus, moving the zone for potential noise, disturbance, discharges, airborne emissions, and oil-spill effects farther away from subsistence whaling areas. Climate change, and economic, employment and demographic effects would be similar between this Alternative and Alternative 2. By reducing potential subsistence impacts, this Alternative would reduce anticipated public health impacts relative to Alternative 2; this difference would be most evident in Kaktovik. As described in section 4.4.1.3.17 and subsections (Beaufort Sea Alternative 1, public health), subsistence forms the foundation of health in rural Alaska Native villages. Adverse effects on subsistence can impact general health and wellbeing, diet and nutrition, injury rates, and rates of nutrition-related chronic diseases such as diabetes, hypertension, and cardiovascular disease.

#### 4.4.5.17.3 Cumulative Effects of Selecting Alternative 5

Deferring this area reduces the overall footprint of the lease sale in critical bowhead whale habitat; therefore, this deferral reduces the cumulative noise effects on migrating bowhead whales pursued by Kaktovik subsistence whalers and consequent effects on public health from Alternative 2—the Proposed Action.

#### 4.4.6.17.1 Beaufort Sea Alternative 6, Deep Water Deferral

Alternative 6 offers for lease approximately 1,766 whole or partial blocks, consisting of 9,096,834 million acres (about 8.8 million hectares). The area removed by the Deepwater Deferral encompasses 4,357 whole blocks, consisting of 24,097,633 million acres (about 9.7 million hectares).

#### 4.4.6.17.2 Direct and Indirect Effects of Selecting Alternative 6 on Public Health

There appears to be relatively little industry interest in the area far offshore, as it holds little resource potential. Additionally, subsistence resources are normally harvested closer to shore, so the potential for disturbance to subsistence resources and practices is very low. On the other hand, the NSB Wildlife Management Department pointed out that resources harvested by Beaufort villages may use the farther offshore areas for feeding. Deferring this area reduces the overall footprint of the lease sale although subsistence resources are normally harvested closer to shore and the potential for disturbance to subsistence resources and practices from activities in this region is very low. Therefore, the extent of reduction in adverse public health effects from Alternative 2 – the Proposed Action – would be negligible.

#### 4.4.6.17.3 Cumulative Effects of Selecting Alternative 6

The extent of reduction in adverse public health effects from Alternative 2 – the Proposed Action – would generally be low.

### 4.5.1 Chukchi Sea Alternative 1, No Action

#### 4.5.1.3.17 Public Health in the Chukchi Sea Planning Area

#### 4.5.1.3.17.1 Introduction

In the following analysis we describe the potential effects to public health from a variety of existing and potential sources. The potential effects of Beaufort and Chukchi Sea lease sales were considered together in the Beaufort Sea No Action Alternative, in Section 4.4.1.17, as well as the historic and present status of oil and gas development and other human activities on the North Slope and adjacent offshore areas. This

is the baseline condition against which future impacts were evaluated. In the case of the No Action Alternative for Chukchi Sea leasing, the environmental consequences would be those effects that could result from reasonably foreseeable future events that did not include any lease sales proposed under this EIS.

#### 4.5.1.3.17.2 Potential Effects Agents to Subsistence Harvests and Resources

The potential effects agents for Public Health in the Chukchi region are the same as those described in section 4.4.1.3.17.1.

#### 4.5.1.3.17.3 Impact Assessment Overview

The coastal communities of the Chukchi Sea – Barrow, Wainwright, Point Hope, and Point Lay – participate in subsistence harvests of marine and terrestrial resources in the region. These resources, subsistence practices, and sociocultural systems, and public health could be affected by the effects agents discussed above.

This discussion is concerned with those communities that potentially could be affected by past and ongoing exploration, development, and production activities in the region. Public Health focuses on health outcomes and factors that determine these outcomes. The Public Health analysis will consider impacts to the following Health Effects Categories (HECs): (1) General Health and Well-being; (2) Psychosocial issues; (3) Accidents and Injuries; (4) Contaminant Exposure; (5) Food, Nutrition, and Physical Activity; (6) Non-communicable and Chronic Disease; (7) Cancer; (8) Infectious Diseases; (9) Maternal-Child Health; (10) Water and Sanitation; (11) Health Services Infrastructure and Capacity; and (12) Occupational/Community Health Intersection.

Public Health is one of the considerations in Environmental Justice. Whereas EJ focuses on the disproportionate public health (and other) impacts to low-income and ethnic minority populations, the Public Health subsections in this EIS address the potential health effects to the NSB community as a whole, including non-EJ populations. Because of the limitations of existing data, some data used in the health effects analysis are specific to the Alaska Native population of the NSB. These statistics will be reported as "Barrow Service Unit" (BSU), whereas statistics for the NSB population as a whole are labeled "NSB."

#### 4.5.1.3.17.4 Factors Affecting Public Health

See Beaufort Sea Alternative I, Section 4.4.1.3.17.3 for a more detailed discussion of the factors affecting health in the region. The factors affecting health in the Chukchi villages are much the same. One important difference, however, would be the need to stage onshore activities supporting OCS development from existing facilities in villages – particularly Barrow and Wainwright – and the creation of a shore-base near Wainwright. Whereas in the Beaufort Sea region much of the activity supporting development could occur using existing onshore industrial facilities, it is projected that exploration and development activities may require transport of equipment and personnel through Wainwright and Barrow, and the construction of a shore-base near Wainwright. This could impact health through (1) a general increase in acculturative stress and change, as described in section 4.4.1.3.13; (2) an increased transient worker population in and near villages, increasing the burden on local services (police, EMS personnel, local services) and infrastructure (water and sanitation systems, roads, and runways); (3) increased noise and disturbance in otherwise isolated villages; (4) the possibility of increased illicit drug and alcohol trafficking associated with a large flux of non-resident workers through the villages; (5) the creation of new roads and infrastructure to the villages (to service pipelines), leading to increased contact with larger urban areas in the state, and the potential for increased hunting pressure on subsistence resources in the region; (6) economic changes related to increased commerce in impacted villages, the potential for inflation, local hire for work on and in shore-bases or other facilities located near the village

and indirect employment in businesses supporting oil and gas activities, and business opportunities for village and/or regional corporations; and (7) potential impacts on subsistence from the construction, operation, and habitat loss associated with onshore facilities supporting OCS development in the Chukchi. These effects were discussed in general for both the Beaufort and Chukchi regions in Beaufort Alternative 1, Section 4.4.1.3.17; they will be reviewed again here relative to reasonably foreseeable activities in the region.

#### 4.5.1.3.17.5 Effects Definitions and Effects Levels

Effects Definitions and Effects Levels are presented in Section 4.4.1.3.17.4.

#### 4.5.1.3.17.6 Potential (Unmitigated) Effects

The potential (unmitigated) effects on Public Health in the Beaufort and Chukchi regions are discussed in detail in section 4.4.1.3.17.5 of the Beaufort Sea No Action Alternative (Alt. I). This section will update that discussion with a more specific focus on the Chukchi.

##### 4.5.1.3.17.6.1 Potential Effects from Disturbance

Potential disturbance effects on public health were discussed for the region in Section 4.4.1.17.5.1. Effects on public health in the Chukchi would be similar, with the following distinctions. Noise levels related to exploration, development, and productions activities – particularly the staging activities that could occur in and near Wainwright and Barrow – could add considerably to noise levels in the village. Noise is associated with a number of adverse health effects. Noise causes psychological effects, including annoyance, stress, and anxiety, and sleep disturbance, which can cause and exacerbate psychosocial problems as well (Passchier-Vermeer W and Passchier W, 2000). Noise causes cognitive delay and school problems in children (Stansfeld S, 2005; Clark et al, 2006). Noise exposure has also been associated with physiologic effects and adverse health outcomes, the most significant of which include hypertension and cardiovascular disease. The strongest associations have been with aircraft and airport noise (Jarup et. al., 2008; Passchier-Vermeer and Passchier, 2000). Increased air traffic in villages would present a health problem if (a) it occurred during typical sleep hours; (b) it contributed substantially to noise levels in schools during school hours; or (c) it increased to levels above recommended health-based safety thresholds based on a 24 hour average. The EPA has established 24 hr average noise thresholds as follows: 45 decibels indoors and 55 decibels outdoors are the upper limits of noise that permit normal activity (sleeping, conversing, working) without interference; 70 decibels is the threshold beyond which chronic exposure may cause hearing loss (EPA, 2007)

##### 4.5.1.3.17.6.2 Potential Effects from Discharges

Potential effects from discharges on public health were discussed for the region in Section 4.4.1.17.5.2. Effects on public health in the Chukchi would be similar, with the following distinctions. The Chukchi environment is different from the Beaufort, and there is less information regarding ocean currents, climate and weather patterns, baseline water quality, benthic flora and fauna, and biology and ecology. As discussed in section 4.4.1.3.17.5.2, these factors influence the dispersion, weathering, bioavailability, and bioaccumulation of contaminants. Consequently, the risks posed by discharges to the public health of Chukchi residents and subsistence users cannot be estimated with certainty.

##### 4.5.1.3.17.6.3 Potential Effects from Large Oil Spills

Potential effects from large oil spills on public health were discussed for the entire region in Section 4.4.1.17.5.3. A spill originating within the Chukchi Sea region could produce indirect impacts felt by communities remote from the sale area and far removed from the spill. Essentially, concerns about subsistence harvests and subsistence food consumption would be shared by all Inupiat and Yup'ik Eskimo communities in the Chukchi (including indigenous people on the Russian Chukchi Sea coast) and Bering seas adjacent to the migratory corridor used by whales and other migrating species. The lack of

the well-established and extensive onshore infrastructure and oil spill response capacity found in the Beaufort region could compromise the efficacy of the response to a large spill in the Chukchi. The harsher weather conditions and movement of pack ice in the Chukchi would also present novel challenges for oil spill cleanup, and could increase the risk of public health problems resulting from exposure to contaminants.

#### 4.5.1.3.17.6.4 Potential Effects from Oil-Spill Response and Cleanup

Potential public health effects from oil spill response and cleanup for the region were discussed in section 4.4.1.3.17.5.4. Cleanup efforts for a large spill could call for 60-190 cleanup workers. Potential effects in the Chukchi region could differ from those in the Beaufort in that the influx of personnel for response would be more likely to pass through local villages. Whether the personnel required for response to a large spill would be accommodated in an enclave such as a shore-base or offshore production facility or in local villages is uncertain. The impacts of influx on health are analyzed in section 4.4.1.3.17.5.4.

#### 4.5.1.3.17.6.5 Potential Effects from Airborne Emissions

The potential effects of airborne emissions on health for the region are discussed in section 4.4.1.3.17.5.5.

#### 4.5.1.3.17.6.6 Potential Effects from Seismic Surveys

Potential public health effects from Seismic Surveys for the region are analyzed in section 4.4.1.3.17.5.6. This discussion highlights differences between the Chukchi and the Beaufort Sea region. Walrus and Beluga figure more prominently in Chukchi Sea subsistence communities (versus Beaufort), though bowhead whales are now (with the recent quoted extended to Pt. Lay) hunted in all NSB Chukchi communities; Point Lay residents rely on the harvest of belugas more than any other village in the Planning Area, and hunt by herding the animals into Kasegaluk Lagoon. Though there is Rosa some evidence of belugas acclimatizing to some boat noise, if noise from boat traffic and seismic-survey activity increased past a threshold point there is the possibility that this herding technique would be less successful and the hunt reduced (Braund and Burnham, 1984; USDOI, MMS, 1987c 1995a, 1998; Huntington and Mymrin, 1996; Huntington, 1999; Mymrin, 1999). The common method use to hunt walruses is to approach the herds as they rest on ice pans in the broken-ice margin of the pack ice. If increased seismic-survey noise caused the dispersal of these herds, hunting success of local residents could be detrimentally affected. Noise and disturbance from seismic-survey boats and other vessels could be a problem, if boat traffic moved near marine mammal-haulout areas. Finally, the NSB Department of Wildlife Management notes more frequent reports of species not commonly seen in the Chukchi such as humpback, fin and minke whales and narwhals in recent years, which may indicate that new species are entering the region from the Bering or Beaufort Seas and could relate to climate change (Rosa C, personal communication, 2008.) The biological significance of these reports as far as the stability of the ecosystem, and how these changes might interact with oil and gas activities, are not known. The public health effects from changes in subsistence related to seismic surveys are analyzed in depth in section 4.5.1.3.17.5.6.

#### 4.5.1.3.17.6.7 Potential Effects from Habitat Loss

Potential effects on public health from habitat loss in the region are discussed in depth in section 4.4.1.3.17.5.7. , and are expected to be similar to the public health effects from habitat loss in the Chukchi.

#### 4.5.1.3.17.6.8 Potential Effects from Economic, Employment, and Demographic Change

Potential effects from economic, employment, and demographic change are discussed in section 4.4.1.3.17.5.8. This discussion highlights differences between the Chukchi and Beaufort Sea regions. The possibility of a shore base near Wainwright could have localized economic effects on this community. Potential effects include influx and pass-through of non-resident workers; immigration to the

community by non-Native workers; although it is anticipated that most workers would be housed in an enclave outside of the town, it is noted that according to a recent count there were 31 vacant houses in Wainwright, which could house workers from outside the region; wear and tear on local infrastructure roads, water and sewer systems, airstrips; inflation secondary to commerce generated by incoming workers; new business opportunities for local residents and native corporations; employment opportunities for residents associated with the shore base and operations support needs.

The health effects benefits and risks associated with economic, employment, and demographic change are addressed in Section 3.4.7 and 4.4.1.3.17.5.8., and key findings are summarized here relative to a potential shore-base near Wainwright. Few studies have monitored or investigated the effects of industrial enclaves on small, isolated communities, but there are a number of potential health concerns. One recent study found a trend toward increased arrest rates and increased EMS calls proportional to the number of active gas wells within a certain radius of a community (Ecosystem Resource Group, 2007). Problems with drugs and alcohol for Arctic indigenous communities near industrial camps has been reported elsewhere as well, though the likelihood in some studies is dependent upon alcohol policies and the proximity and ease of access between the community and the enclave (Gibson and Klinck, 2005; North Slave Metis Association, 2002). In Nuiqsut, residents have commented that the ice road that now connects the community with Alpine and the Alaska road system in winter (a feature desired by many residents), is now commonly used to bring drugs and alcohol into the community, compromising the efficacy of the local prohibition ordinance, and increasing psychosocial problems and the risk of injury (CIT.). There are several likely mechanisms for these observed changes. The rapid influx of non-resident personnel to or through a community could exacerbate tensions and disrupt social cohesion, intensifying psychosocial health problems. (1) A rapid infusion of income (through native corporation revenues, employment, and support businesses) coupled with immigration of workers earning high wages can increase inflation and economic disparity, exacerbating stress and tension in the community. (2) The influx of non-residents (workers or recreational visitors on ice to or through a village associated with or lying near a shore-based enclave can exacerbate cross-cultural tensions and disrupt social cohesion. (3) The flow of non-resident workers to and through a community can overstress local law enforcement and EMS staffing, compromising the efficacy of local alcohol prohibition ordinances. Finally, the influx of non-resident workers to or through a community also increases the likelihood of infectious disease transmission, and would be particularly concerning for a disease such as HIV, which is markedly less common in the NSB than in urban areas of Alaska or the U.S.; this has commonly been recognized as an unintended consequence of industrial development in and near indigenous communities (IFC 2007; Utzinger et al., 2005).

### 4.5.1.3.17.6.9 Potential Effects from Climate Change

Potential public health effects from climate change were discussed previously in Section 4.4.1.3.17.5.9 in relation to the predicted and observed changes in the biological and physical environment. Those effects are similar to those expected in the Chukchi region. In the Chukchi area, changes in the biological and physical environment that could profoundly shape the health of the region are already apparent, and are likely to accelerate in coming decades (ACIA 2005; IPCC 2007). Shore erosion in Shishmaref, Kivalina, Wainwright, and Barrow has become increasingly severe in recent years, as sea-ice formation occurs later, allowing wave action from storms to cause greater damage to the shoreline. The NSB Department of Wildlife Management notes more frequent reports of species not commonly seen in the Chukchi such as humpback, fin and minke whales and narwhals in recent years, which may indicate that new species are entering the region from the Bering or Beaufort Seas and could relate to climate change (Rosa C, personal communication, 2008.) The biological significance of these reports as far as the stability of the ecosystem, and how these changes might interact with oil and gas activities, are not known.

### 4.5.1.3.17.7 Mitigation

Section 4.4.1.3.17.6.1 discusses mitigation measures assumed to be in place based on past lease sales. Section 4.4.1.3.17.6.2 discusses potential new mitigation measures to address newly identified health effects, and these would be the same for this alternative.

### 4.5.1.3.17.8 Anticipated Effects on Public Health

Anticipated effects on public health were previously discussed in Section 4.4.1.3.17.7 (General Past and Present Effects and Reasonably Foreseeable Future Effects), and 4.4.1.3.17.7.1-10, specific anticipated effects, and those discussion apply to the Chukchi No Action alternative as well. The following subsections analyze the impact of the Chukchi No Action alternative added to the other past, present, and reasonably foreseeable future actions regardless of what agency or entity undertakes those actions. Reasonably foreseeable future actions are described in section 4.2.

#### 4.5.1.3.17.8.1 Anticipated Effects from Disturbance

Anticipated effects from disturbance were discussed in section 4.4.1.3.17.7.1. Effects on public health in the Chukchi would be similar. The baseline ambient noise levels in villages that will be used for staging for Chukchi operations would experience an increase in noise levels, primarily due to aircraft; this would be a concern in Wainwright, and to some extent in Barrow based on the anticipated staging and shore-base operations in those villages. Aircraft noise is associated with cognitive delay in children, hypertension, cardiovascular disease, sleep disturbance, and annoyance. If increase in vessel noise levels offshore were to compromise Point Lay's beluga hunt, nutritional health problems and the risk of diabetes and related nutritional diseases would increase in proportion to the severity and chronicity of the harvest problems. Mitigation for these problems was analyzed in 4.4.1.3.17.7.1, and would be similar for this alternative.

#### 4.5.1.3.17.8.2 Anticipated Effects from Discharges

The anticipated public health consequences from discharges and potential new mitigation measures were analyzed in section 4.4.1.3.17.7.2, and would be similar for this Alternative. Differences in discharge-related health effects relate to the notable differences in the Chukchi environment, such as ocean currents, temperatures, benthic ecology, and macrofauna biology. These characteristics could influence the reactions that drive bioavailability, the distribution, and the fate of discharges. There are relatively few baseline data on which to rely in the Chukchi environment.

#### 4.5.1.3.17.8.3 Anticipated Effects from Large Oil Spills

Anticipated public health consequences form large oil spills were analyzed in Section 4.4.1.3.17.7.3, along with potential new mitigation measures for public health effects. Effects for the Chukchi No Action alternative would be similar, although there are notable differences in the environment that could affect the fate and distribution of oil, and the specific subsistence impacts. For example, and would be similar for the Chukchi No Action alternative. In the Chukchi Sea the active-ice, or ice-flaw zone is an important habitat for marine mammals such as bowhead and beluga whales, walrus, seals, and other marine mammals. Seals, walrus, and beluga whales would be most vulnerable to spills contacting this zone; polar bears would be most vulnerable to spills contacting the flaw zone or the coast.

#### 4.5.1.3.17.8.4 Anticipated Effects from Oil Spill Response and Cleanup

Anticipated public health effects from oil spill response and cleanup were analyzed in Section 4.4.1.3.17.7.4, along with potential new mitigation measures for public health effects. Effects in the Chukchi region could differ from those in the Beaufort in that the influx of personnel for response would be more likely to pass through local villages. Whether the personnel required for response to a large spill would be accommodated in an enclave such as a shore-base or offshore production facility or in local villages is uncertain.

#### 4.5.1.3.17.8.5 Anticipated Effects from Airborne Emissions

The anticipated public health effects from airborne emissions are discussed in Section 4.4.1.3.17.7.5, along with new potential mitigation measures. Onshore, new BLM Stipulation A-10 could also mitigate the cumulative impacts of air pollution on health, as discussed in section 4.4.1.3.17.7.5.

#### 4.5.1.3.17.8.6 Anticipated Effects from Seismic Surveys

The anticipated public health effects from Seismic Surveys, along with the efficacy of potential new mitigation measures for health, were discussed in section 4.4.1.3.17.7.6. Walrus and Beluga figure more prominently in Chukchi Sea subsistence communities (versus Beaufort), though bowhead whales are now (with the recent quoted extended to Pt. Lay) hunted in all NSB Chukchi communities; Point Lay residents rely on the harvest of belugas more than any other village in the Planning Area, and hunt by herding the animals into Kasegaluk Lagoon. Though there is some evidence of belugas acclimatizing to some boat noise, if noise from boat traffic and seismic-survey activity increased past a threshold point there is the possibility that this herding technique would be less successful and the hunt reduced (Braund and Burnham, 1984; USDOI, MMS, 1987c 1995a, 1998; Huntington and Mymrin, 1996; Huntington, 1999; Mymrin, 1999). Decreased harvest success would contribute incrementally to psychosocial health problems, as well as compromising the protective effects of a traditional diet and compromising nutritional health and food security; mitigation could reduce the adverse effects of decreased harvest, but would not be expected to eliminate them entirely, as discussed in Section 4.4.1.3.17.7.6.

#### 4.5.1.3.17.8.7 Anticipated Effects from Habitat Loss

The anticipated public health effects from habitat loss in the region are analyzed in section 4.4.1.3.17.7.7, along with the efficacy of potential new mitigation measures for public health, and would be similar for this alternative.

#### 4.5.1.3.17.8.8 Anticipated Effects from Economic, Employment, and Demographic Change

The anticipated public health effects from economic, employment, and demographic change were discussed in section 4.4.1.17.7.8, and the potential effects of these changes relative to Chukchi development were analyzed in section 4.5.1.3.17.8. A base of operations would be needed for Chukchi oil and gas exploration and development. Exploration activities would likely be staged mostly out of Barrow and Wainwright initially. Future development and production operations would necessitate a shore base, which would likely be built near Wainwright (USDOI MMS 2007 [193 FEIS]). It is unlikely but not certain under this scenario that large numbers of non-resident workers would immigrate to Wainwright, although there are vacant housing units which could be occupied. It is likely that many workers would be housed at an enclave separated from the village. In the case of Nuiqsut, an ice road was constructed between the village and the CPF/work camp, and the village now hosts oil and gas-related workers at a camp located in the village. It is not known if a similar scenario would be desired by Wainwright or industry. As discussed in Potential Effects above (Section 4.5.1.3.17.6.8), the general large increase in flow of non-resident workers to and through Wainwright, and the shore-base scenario, create the potential for substantial health effects. Unless police and EMS staffing were increased, current levels of police presence would not be adequate to ensure public safety and to enforce drug and alcohol trafficking laws. This could compromise the efficacy of local alcohol ordinances, and lead to more problems with drugs and alcohol in the community. Large-scale economic changes – such as could occur if the village corporation develops business agreements with industry, residents find local temporary or permanent employment, and influx creates inflation – could create considerable economic disparity in the community which might increase tensions and exacerbate social problems. Influx and industrial work camps near indigenous communities have also unfortunately sometimes been associated with the spread of infectious diseases, with sexually transmitted infections being a particular concern. Because the prevalence of HIV infection in the region is far lower than urban areas of the state or U.S., there is a risk that a large influx of workers could trigger an increase in HIV rates. Potential new mitigation measure 8

would provide a system through which the service and infrastructure costs associated with staging and a shore-base could be monitored and recouped by the NSB. Potential new mitigation measure 9 would establish a process through which the health effects of proposals for shore-bases, roads, and other major infrastructure required to support OCS activities would be evaluated and an appropriate development stage.

#### 4.5.1.3.17.8.9 Anticipated Effects from Climate Change

The anticipated public health effects from economic, employment, and demographic change were discussed in section 4.4.1.3.17.7.9. Altered availability and distribution of subsistence resources is expected to alter the distribution and species of resources available to hunters, which will impact dietary health; it could become more difficult to contact subsistence resources, because of less reliable ice conditions and more unstable ocean and weather conditions, which would affect nutrition, food security, and nutritionally-related chronic illness; infrastructure damage (such as damage to water and sewer systems) from melting permafrost would compromise basic public health and safety. If accelerated erosion leads to the need to relocate a village, the health effects of relocation could be major.

### 4.5.1.3.17.9 Direct and Indirect Effects of Chukchi Sea Alternative I on Public Health

There would be no direct or indirect impacts to public health if Lease Sales 212 and 221 if they were not conducted.

## Chukchi Sea Alternative 2, Proposed Action

### 4.5.1.4 Public Health in the Chukchi Sea Planning Area

Public health in the Chukchi planning area is subject to the same potential effects as previously described in Sections 4.4.1.3.17.5.1-10 and 4.5.1.3.17.6.1-9, and the same cumulative past, present, and reasonably foreseeable actions as described in Sections 4.4.1.3.17.7-4.4.1.3.17.10 and 4.5.1.3.17.8-4.5.1.3.17.8.9. This section describes the impact on public health resulting from the incremental impact of this action--the Proposed Action alternative--and adding it to other past, present, and reasonably foreseeable future actions regardless of what agency or entity undertakes such actions. Reasonably foreseeable future actions are described in Section 4.2. Mitigation measures are described in Section 4.4.1.3.17.6.1; potential mitigation measures for newly described health effects are described in section 4.4.1.3.17.6.2.

#### 4.5.1.4.17 Anticipated Effects from Disturbance

Public health in the Chukchi Sea Planning Area is subject to the same potential effects from vessel and aircraft disturbance previously described in sections 4.4.1.3.17.5.1 and 4.5.1.3.17.6.1, and the same anticipated effects and cumulative past, present, and reasonably foreseeable future effects described in sections 4.4.1.3.17.7-4.4.1.3.17.7.1, and 4.5.1.3.17.8.1. This section analyzes the impact of the Proposed Action Alternative, added to other past, present and reasonably future foreseeable future actions regardless of what agency or entity undertakes such actions.

Under the Proposed Action, during the exploration phase for Chukchi Sea sales, Barrow and Wainwright would be used as air-support bases for offshore operations. Personnel and freight would be transferred at either location for the helicopter flights to offshore locations. There could be between one and three flights a day, depending on the level of offshore activity. Chukchi Lease Sale 193 predicted that for oil and gas activities on tracts leased in this sale, there could be 4 helicopter flights/day for seismic exploration, 13/day for exploration drilling, 5/day during shore base construction, and 2/day for production. The existing facilities at Barrow and Wainwright appear sufficient to meet these needs. Vessels used in support of exploration activities staging out of Barrow would have to anchor offshore, as Barrow has no port facilities (Sale 193). The development of a shore-base near Wainwright could also

lead to increased barge traffic in the region during the open water season, and ice road traffic during the winter month.
As described in sections 4.4.1.3.15.5.1 and 4.5.1.3.17.6.1, disturbance could cause direct health effects (noise-related health problems such as developmental delay and poor school performance, high blood pressure, and cardiovascular disease, and annoyance and stress), and indirect health effects that would relate primarily to impacts to subsistence harvest. If belugas acclimated to offshore disturbance and seismic, Point Lay's beluga harvest could be substantially reduced, increasing the risk of nutritional health effects, food insecurity, and diet-related diseases such as diabetes, high blood pressure, and cardiovascular disease; a major effect on subsistence such as a decline in beluga harvest over more than one season, would also have impacts on psychosocial health problems and well-being. Noise levels in the village that exceeded EPA recommended levels could have adverse health effects; if subsistence effects impacted a resource that contributes substantially to the local diet, effects would be moderate if the impact lasted one season, and major if the impact were ongoing. Mitigation – both existing measures and potential new measures, are discussed in Sections 4.4.1.3.17.6-4.4.1.3.17.6.2, and in Anticipated Effects in Sections 4.4.1.3.17.7.1 and 4.4.1.3.17.8.1. Mitigation could effectively reduce noise-related health problems to negligible if instituted effectively. Mitigation for nutritional problems could reduce the risk of food insecurity and chronic illnesses such as diabetes and cardiovascular disease, but would not eliminate the risk if subsistence impacts were ongoing.

### 4.5.1.4.18 Anticipated Effects from Discharges

Public health in the Chukchi Sea Planning Area would be subject to the same potential effects from discharges previously described in Sections 4.4.1.3.17.5.2 and 4.5.1.3.17.6.2, and the same anticipated and cumulative past, present, and reasonably foreseeable future effects described in Sections and the same anticipated effects described in sections 4.4.1.3.17.7.2 and 4.5.1.3.17.8.2. Differences in discharge-related health effects relate to the notable differences in the Chukchi environment, such as ocean currents, temperatures, benthic ecology, and macrofauna biology. These characteristics could influence the reactions that drive bioavailability, the distribution, and the fate of discharges. There are relatively few baseline data on which to rely in the Chukchi environment. Mitigation is described in Sections 4.4.1.3.17.6-4.4.1.3.17.6.2, and the efficacy analyzed in Section 4.4.1.3.17.7.2; effectiveness would be similar for this Alternative.

### 4.5.1.4.19 Anticipated Effects from Large Oil Spills

Public health in the Chukchi Sea Planning Area would be subject to the same potential effects from large oil spills previously described in Sections 4.4.1.3.17.5.3 and 4.5.1.3.17.6.3, and the same anticipated effects described in Sections 4.4.1.3.17.7.3 and 4.5.1.3.17.8.3. The anticipated public health effects from a large spill under this alternative would be the same as these effects, if a spill actually occurred. Section 4.4.2.3.17 presents the results of the OSRA for this alternative. The large oil spill occurrence estimate is based on the estimated volume of oil produced. The NSB has pointed out that the OSRA would be strongly impacted by oil prices, in that a high level of industrial activity (and therefore a higher risk of spills) would be predicted if oil prices are higher. Mitigation is described in Sections 4.4.1.3.17.6-4.4.1.3.17.6.2, and the efficacy analyzed in Section 4.4.1.3.17.7.3; effectiveness would be similar for this Alternative.

### 4.5.1.4.20 Anticipated Effects from Oil Spill Response and Cleanup

Public health in the Chukchi Sea Planning Area would be subject to the same potential effects from large oil spill response and cleanup previously described in Sections 4.4.1.3.17.5.4 and 4.5.1.3.17.6.4, and the same anticipated effects described in Sections 4.4.1.3.17.7.4 and 4.5.1.3.17.8.4. As discussed in Section 4.5.1.3.17.6.4, effects in the Chukchi region could differ from those in the Beaufort in that the influx of personnel for response would be more likely to pass through local villages. Whether the personnel required for response to a large spill would be accommodated in an enclave such as a shore-base or

offshore production facility or in local villages is uncertain. Mitigation is described in Sections 4.4.1.3.17.6-4.4.1.3.17.6.2, and the efficacy analyzed in Section 4.4.1.3.17.7.3; effectiveness would be similar for this Alternative.

#### 4.5.1.4.21 Anticipated Effects from Airborne Emissions

Public health in the Chukchi Sea Planning Area would be subject to the same potential effects from airborne emissions previously described in Sections 4.4.1.3.17.5.5 and 4.5.1.3.17.6.5, and the same anticipated effects described in Sections 4.4.1.3.17.7.5 and 4.5.1.3.17.8.5. The addition of new leased areas under this alternative might increase the likelihood of active exploration in the Chukchi (and the associated emissions), and might increase the chance of a large oil discovery and ensuing development and production. Also, under the Proposed Action alternative (although this could also occur through activity on existing Chukchi leases), a shore base would be an additional source of emissions. The impact of air quality on the health of local residents – particularly in Wainwright – would depend on the type and amount of pollutants emitted, prevailing winds, climate and weather, location of major emissions sources relative to communities and relative to important subsistence use areas, and the baseline health status of residents in the community (sensitive populations include the very young, elders, and people with chronic illnesses.) Mitigation is described in Sections 4.4.1.3.17.6-4.4.1.3.17.6.2, and the efficacy analyzed in Section 4.4.1.3.17.7.3; effectiveness would be similar for this Alternative.

#### 4.5.1.4.22 Anticipated Effects from Seismic Surveys

Public health in the Chukchi Sea Planning Area would be subject to the same potential effects from Seismic Surveys previously described in Sections 4.4.1.3.17.5.6 and 4.5.1.3.17.6.6, and the same anticipated effects described in Sections 4.4.1.3.17.7.6 and 4.5.1.3.17.8.6. Impacts to public health from seismic surveys would relate mainly to subsistence impacts, as described in section 4.4.1.3.17.5.6. Up to four open-water seismic surveys (both 2D and 3D) could be conducted seasonally in the Chukchi Sea Planning Area during the open-water season. Conflict avoidance agreements (CAA) between the AEWC and oil operators conducting one or perhaps two seismic-survey operations per open-water season have tended to mitigate disruptions to the fall hunt in these communities in the past, but the magnitude of three concurrent seismic surveys and the breakdown of the CAA process would test the ability of survey operators and whalers to coordinate their efforts to prevent disruptions to the hunt. Barrow's fall bowhead whale hunt could be particularly vulnerable. Noise effects from multiple seismic surveys to the west in the Chukchi Sea and to the east in the Beaufort Sea potentially could cause migrating whales to deflect farther out to sea, forcing whalers to travel farther—increasing the effort and danger of the hunt—and increasing the likelihood of whale-meat spoilage, as the whales would have be towed from greater distances. If seismic activity resulted in reduced harvest success, or deflected whales farther offshore, there could be a number of health effects, including: (1) Increased risk of injury for whaling crews having to travel father offshore to locate and successfully strike whales. (2) Impacts to the nutritional system, which could increase food insecurity and nutritional deficiencies, particularly if the subsistence impacts took place over more than one season; (3) decreases in harvest amounts of key subsistence species were chronic, could incrementally increase the risk of diabetes and other chronic diseases This effect would be particularly concerning if more than one village were affected, because sharing networks would be less likely to be able to compensate for the loss. Effects would be major if serious injuries resulted, or if chronic disruption of subsistence led to dietary change. Mitigation is described in Sections 4.4.1.3.17.6-4.4.1.3.17.6.2, and the efficacy analyzed in Section 4.4.1.3.17.7.3; effectiveness would be similar for this Alternative.

#### 4.5.1.4.23 Anticipated Effects from Habitat Loss

Public health in the Chukchi Sea Planning Area would be subject to the same potential effects from Seismic Surveys previously described in Sections 4.4.1.3.17.5.7 and 4.5.1.3.17.6.7, and the same anticipated effects described in Sections 4.4.1.3.17.7.7 and 4.5.1.3.17.8.7. Mitigation is described in

Sections 4.4.1.3.17.6-4.4.1.3.17.6.2, and the efficacy analyzed in Section 4.4.1.3.17.7.3; effectiveness would be similar for this Alternative.

#### 4.5.1.4.24 Anticipated Effects from Economic, Employment, and Demographic Change

Public health in the Chukchi Sea Planning Area would be subject to the same potential effects from Economic, Employment, and Demographic Change previously described in Sections 4.4.1.3.17.5.8 and 4.5.1.3.17.6.8, and the same anticipated effects described in Sections 4.4.1.3.17.7.8 and 4.5.1.3.17.8.8, which will be reviewed and summarized here. Wainwright could experience major effects. Noticeable disruption most likely would result during development from the placement of onshore infrastructure (a shore-base), with the most prominent effect being the change in land use that comes about by introduced industrialization. Wainwright would experience other effects to social organization, cultural values, and institutional organization, as well, for a period exceeding 2-5 years. Economic and employment effects could involve some increases in direct and indirect employment; income from employment; opportunities for local business and native corporation revenues; and the potential for inflation. Influx of non-residents to and through communities could also lead to cultural strain, and place a stress of local infrastructure and services. The importation, possession, and sale of alcohol are prohibited in Wainwright. Enforcement of this prohibition by public safety officers at originating airports in Alaska (Anchorage, Fairbanks, and Barrow, for example) and at Wainwright would need to increase with the frequency of flights: this could place a stress on the finances of the NSB, and could increase the risk of illicit drug and alcohol importation. New roads or ice roads linking the community with the shore-base or the Alaska road system could compound this risk. Communities in California that have OCS-related onshore infrastructure established impact monitoring and mitigation programs with industry. These programs ascertained the effects and recovered costs for services provided by local government (USDOI, MMS, 2000b). These monitoring and mitigation programs and other measures have facilitated project approval when there is uncertainty over the cause and effect of project-related impacts, and North Slope communities could benefit from a similar program (Woolley and Lima, 2003; Sale 193). Potential new mitigation measure 8 would institute a similar program. Mitigation is described in Sections 4.4.1.3.17.6-4.4.1.3.17.6.2, and the efficacy analyzed in Section 4.4.1.3.17.7.3; effectiveness would be similar for this Alternative.

#### 4.5.1.4.25 Anticipated Effects from Climate Change

Public health in the Chukchi Sea Planning Area would be subject to the same potential effects from Climate Change previously described in Sections 4.4.1.3.17.5.9 and 4.5.1.3.17.6.9, and the same anticipated effects described in Sections 4.4.1.3.17.7.9 and 4.5.1.3.17.8.9.

#### 4.5.1.4.26 Direct and Indirect Effects of Chukchi Sea Alternative I on Public Health

### 4.5.3.17.1 Chukchi Sea Alternative 3, Coastal Deferral

This option is analyzed for protection of subsistence-use zones and wildlife areas. This alternative would offer for leasing all of the area described for Chukchi Sea Alternative 2 except for a corridor located landward of the planning area. Chukchi Sea Alternative 3 would offer 6,444 whole or partial blocks, comprising 35,374,261 million acres (about 14.3 million hectares). The area that would be removed by the Coastal Deferral consists of 882 whole or partial blocks, approximately 4,818,605 million acres (about 1.9 million hectares), approximately 12% of the proposed sale area.

### 4.5.3.17.2 Direct and Indirect Effects of Selecting Alternative 3 on Public Health

This deferral would offer protection of subsistence hunts for whales and other marine mammals important to the communities of Barrow, Wainwright, Point Lay, and Point Hope. Moving the shoreward boundary of the lease sale offshore would move the zone for potential noise, disturbance, and oil-spill effects farther away from the Chukchi Sea spring-lead system, nearshore coastal waters, and onshore habitats. Resources in the area could still be affected by a large oil spill that occurred in the sale area. The reduction in economic, employment, and demographic change related to influx of non-resident workers to

and through Chukchi villages would be expected to be minimal compared with Alternative 2 – the Proposed Action. Public health effects would therefore be reduced mainly through reduction in subsistence-related health effects; as described in section 4.4.1.3.17 and subsections (Beaufort Sea Alternative 1, public health), subsistence forms the foundation of health in rural Alaska Native villages, which would result in a lower incremental risk of adverse subsistence-related health effects on general health and wellbeing, diet and nutrition, injury rates, and rates of nutrition-related chronic diseases such as diabetes, hypertension, and cardiovascular disease. This Alternative would also prevent discharges in some areas used by subsistence hunters in the Chukchi region, which could reduce subsistence-related health effects by allaying community fears about contamination, and could also result in a small incremental reduction in the risk posed by contamination of subsistence resources by OCS discharges. Airborne emissions from OCS activities would also occur farther from shore and farther from subsistence use areas, resulting again in a small incremental reduction in the risk of emissions-related health effects.

#### 4.5.3.17.3 Cumulative Effects of Selecting Alternative 3

Deferring this area reduces the likely impacts on subsistence resources in key nearshore subsistence regions. It would also reduce the risk that people would limit consumption of subsistence resources because of fears of contamination. Vulnerable populations (such as elders, people with chronic lung and cardiovascular disease, and infants) – particularly subsistence hunters – could benefit from a reduced chance of exposure to unhealthful levels of air pollution.

### 4.5.4.17.1 Chukchi Sea Alternative 4, Ledyard Bay Deferral

The area deferred by the Ledyard Bay Deferral consists of 191 whole or partial blocks and addresses issues of protecting a critical habitat area designated by the Fish and Wildlife Service for the protection of Spectacled and Steller's eiders.

#### 4.5.4.17.2 Direct and Indirect Effects of Selecting Alternative 4 on Public Health

By deferring 191 whole or partial blocks along the shoreward edge of the sale area, impacts to Point Lay nearshore subsistence resources, habitats, and hunting areas would potentially be reduced. Moving the shoreward boundary of the lease sale offshore would prohibit leasing, exploration, development, and production activities in the deferred area; thus, moving the zone for potential noise, disturbance, and oil-spill effects farther away from the Chukchi Sea spring-lead system, nearshore coastal waters, onshore habitats, and Point Lay marine mammal harvest areas. Health effects in Point Lay would be reduced primarily through reduction in subsistence impacts, which would result in a lower incremental risk of adverse subsistence-related health effects on general health and wellbeing, diet and nutrition, injury rates, and rates of nutrition-related chronic diseases such as diabetes, hypertension, and cardiovascular disease. This Alternative would also prevent discharges in some areas used by subsistence hunters from Point Lay, which could reduce subsistence-related health effects by allaying community fears about contamination, and could also result in a small incremental reduction in the risk posed by contamination of subsistence resources by OCS discharges. Airborne emissions from OCS activities would also occur farther from shore and farther from subsistence use areas, resulting again in a small incremental reduction in the risk of emissions-related health effects.

#### 4.5.4.17.3 Cumulative Effects of Selecting Alternative 4

Deferring this area reduces the likely impacts on subsistence resources in key subsistence areas used by Point Lay, thereby reducing the cumulative impacts of past, present, and reasonably foreseeable actions on the public health of this village. Vulnerable populations (such as elders, people with chronic lung and cardiovascular disease, and infants) – particularly subsistence hunters – could benefit from an incrementally reduced chance of exposure to unhealthful levels of air pollution.

### 4.5.5.17.1 Chukchi Sea Alternative 5, Hanna Shoal Deferral

This alternative addresses issues associated with minimizing impacts on habitat associated with Hanna Shoal that has been documented as an important feeding area for Pacific walrus and grey whales.

### 4.5.5.17.2 Direct and Indirect Effects of Selecting Alternative 5 on Public Health

By prohibiting leasing, exploration, development, and production activities in the deferred area, the zone for potential noise, disturbance, and oil-spill effects would be moved farther away Hanna Shoal and afford greater protection for Pacific walrus, an important subsistence resource to Chukchi Sea coastal communities.

Resources in this area could still be affected by a large oil spill that occurred elsewhere in the sale area, and pipeline routes from further offshore areas would still cross deferred areas. There would be no reduction in effects from potentially permitted seismic surveys onshore or in the sale area. Health effects in Chukchi villages would be reduced primarily through reduction in subsistence impacts, which would result in a lower incremental risk of adverse subsistence-related health effects on general health and wellbeing, diet and nutrition, injury rates, and rates of nutrition-related chronic diseases such as diabetes, hypertension, and cardiovascular disease.

### 4.5.5.17.3 Cumulative Effects of Selecting Alternative 5

Deferring this area reduces the overall footprint of the lease sale in critical Pacific walrus habitat. By reducing cumulative impacts on subsistence resources, an expected consequent reduction of effects on sociocultural systems would be expected from Alternative 2—the Proposed Action.

### 4.5.6.17.1 Chukchi Sea Alternative 6, Deep Water Deferral

This deferral would prohibit leasing, exploration, development, and production activities in the deferred area. There is little industry interest in the area far offshore, as it holds little resource potential. Additionally, subsistence resources are normally harvested closer to shore, so the potential for disturbance to subsistence resources and practices is very low.

### 4.5.6.17.2 Direct and Indirect Effects of Selecting Alternative 6 on Public Health

By prohibiting leasing, exploration, development, and production activities in the deferred area, the zone for potential noise, disturbance, and oil-spill effects would be moved farther away Hanna Shoal and afford greater protection for Pacific walrus, an important subsistence resource to Chukchi Sea coastal communities.

Resources in this area could still be affected by a large oil spill that occurred elsewhere in the sale area, and pipeline routes from further offshore areas would still cross deferred areas. There would be no reduction in effects from potentially permitted seismic surveys onshore or in the sale area. Health effects in Chukchi villages would be reduced primarily through reduction in subsistence impacts, which would result in a lower incremental risk of adverse subsistence-related health effects on general health and wellbeing, diet and nutrition, injury rates, and rates of nutrition-related chronic diseases such as diabetes, hypertension, and cardiovascular disease.

### 4.5.6.17.3 Cumulative Effects of Selecting Alternative 6

Deferring this area reduces the overall footprint of the lease sale in critical Pacific walrus habitat. By reducing cumulative impacts on subsistence resources, an expected consequent reduction of effects on public health would be expected from Alternative 2—the Proposed Action.

## Table 1. Health Impact Categories

| HEALTH IMPACT CATEGORIES | |
|---|---|
| **Health Impact Category** | **Typical Outcomes/Issues considered in each category** |
| 1. General Health and Wellbeing | • Population health indicators (life expectancy, mortality, infant mortality, child <5 mortality; DALYs);<br>• General measures of overall community well-being (eg BRFSS well-being questions; Quality of Life Index -- http://en.wikipedia.org/wiki/Quality_of_life) |
| 2. Psychosocial/Gender Issues | • Depression, anxiety<br>• Suicide<br>• Substance/alcohol abuse<br>• Violence/homicide<br>• Cultural integrity/change<br>• Public safety/enforcement |
| 3. Accidents and Injuries | • unintentional injury |
| 4. Contaminant Exposure | [Health outcomes in this category depend on the specific contaminant exposure. Could include:]<br>• Cancer<br>• Developmental delay<br>• Acute poisonings<br>• Thyroid/endocrine disease<br>• Respiratory disease |
| 5. Food, Nutrition, and Physical Activity | • Subsistence intake/dietary studies<br>• Micronutrient deficiencies<br>• Food security<br>• Physical activity |
| 6. Non-communicable and chronic disease | • Metabolic Disorders (Diabetes, HTN, Obesity, hyperlipidemia, cardiovascular disease)<br>• Cardiovascular disease<br>• COPD/Asthma<br>• Endocrine disorders<br>• Developmental disorders<br>• Cancer |
| 7. Infectious Diseases | • Respiratory infections<br>• Skin infections<br>• Sexually transmitted infections<br>• Gastrointestinal infections<br>• Vector-borne (eg West Nile virus)<br>• Zoonotic infections (eg echinococcus)<br>• Bloodborne infections |
| 8. Maternal-Child Health | • |
| 9. Water and Sanitation | • Level of water/sewer service |
| 10. Health Services Infrastructure and Capacity | • Type of health services available<br>• Staffing of health services |
| 11. Occupational/Community Health Intersection | This category does not include occupational health data, which are under regulation of OSHA. This category addresses issues where worker health can have overlap with community public health concerns. Issues addressed here could include but are not limited to:<br>• Workplace health screening and immunization protocols, if interaction between workers and the community is planned.<br>• Drug and alcohol policy and enforcement<br>• Cultural orientations<br>• STI transmission prevention strategies. |

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# Seismic Survey Mitigation Measures: Arctic Ocean

The mitigation measures which follow are: (1) consistent with environmental policy as required by the National Environmental Policy Act (NEPA), Endangered Species Act (ESA), and Marine Mammal Protection Act (MMPA); and (2) comply with 40 CFR 1500.2(f) regarding the requirements for Federal agencies to avoid or minimize any possible adverse effects of their actions upon the quality of the human environment. The mitigation measures also fulfill Minerals Management Service's (MMS) statutory mission and responsibilities, i.e., to permit and authorize seismic surveys that are technically safe and environmentally sound while considering environmental, technical, and economic factors.

The following mitigation measures (in concert with applicable MMS's standard stipulations, http://www.mms.gov/alaska/re/permits/stips1-5.htm) are to be implemented:

- No solid or liquid explosives shall be used without specific approval.
- Permittee operations shall be conducted in a manner to ensure that they will not cause pollution, cause undue harm to aquatic life, create hazardous or unsafe conditions, or unreasonably interfere with other uses of the area. Any difficulty encountered with other uses of the area or any conditions that cause undue harm to aquatic life, pollution, or could create a hazardous or unsafe condition as a result of the operations under this permit shall be reported to the Regional Supervisor/Resource Evaluation. Serious or emergency conditions shall be reported without delay.
- Permittee operations shall maintain a minimum spacing of 15 miles between the seismic-source vessels for separate operations. The MMS must be notified by means of the weekly report whenever a shut down of operations occurs in order to maintain this minimum distance.
- Permittee operators shall use the lowest sound levels feasible to accomplish their data-collection needs.
- Vessels and aircraft shall avoid concentrations or groups of whales. Permittee operators shall, at all times, conduct their activities at a maximum distance from such concentrations of whales. Under no circumstances, other than an emergency, shall aircraft be operated at an altitude lower than 1,000 feet above sea level (ASL) when within 1,500 lateral feet of groups of whales. Helicopters shall not hover or circle above such areas or within 1,500 lateral feet of such areas.
- When weather conditions do not allow a 1,000-foot ASL flying altitude, such as during severe storms or when cloud cover is low, aircraft may be operated below the 1,000-foot ASL altitude stipulated above. However, when aircraft are operated at altitudes below 1,000 feet ASL because of weather conditions, the operator must avoid known whale-concentration areas and should take precautions to avoid flying directly over or within 1,500 feet of groups of whales.
- When the Permittee operates a vessel near a concentration of whales, every effort and precaution shall be taken to avoid harassment of these animals. Therefore, vessels shall reduce speed when within 900 feet of whales and those vessels capable of steering around such groups should do so. Vessels shall not be operated in such a way as to separate members of a group of whales from other members of the group.
- Vessel operators shall avoid multiple changes in direction and speed when within 900 feet of whales. In addition, operators shall check the waters immediately adjacent to a vessel to ensure that no whales will be injured when the vessel's propellers (or screws) are engaged.
- Small boats shall not be operated at such a speed as to make collisions with whales likely. When weather conditions require, such as when visibility drops, vessels shall adjust speed accordingly to avoid the likelihood of injury to whales.
- When any operator becomes aware of the potentially harassing effects of operations on whales, or when any operator is unsure of the best course of action to avoid harassment of whales, every measure to avoid further harassment shall be taken until the National Marine Fisheries Service

(NMFS) is consulted for instructions or directions. However, human safety shall take precedence at all times over the guidelines and distances recommended herein for the avoidance of disturbance and harassment of whales.

- The Permittee shall notify MMS, NMFS, and U.S. Fish and Wildlife Service (FWS) in the event of any loss of cable, streamer, or other equipment that could pose a danger to marine mammals and other wildlife resources.
- Seismic cables and airgun arrays shall not be towed in the vicinity of fragile biocenoses (e.g., the Boulder Patch, kelp beds), unless MMS determines the proposed operations can be conducted without damage to the fragile biocenoses. Seismic-survey and support vessels shall not anchor in the vicinity of fragile biocenoses as identified by MMS or may be discovered by the operator during the course of their operations, unless there is an emergency situation involving human safety and there are no other feasible sites in which to anchor at the time. The Permittee shall report to MMS any damage to fragile biocenoses as a result of their operations.
- To help avoid causing bird collisions with seismic survey and support vessels, seismic and surface support vessels will minimize the use of high-intensity work lights, especially within the 20-meter-bathymetric contour. High-intensity lights will be used only as necessary to illuminate active, on-deck work areas during periods of darkness or inclement weather (such as rain or fog), otherwise they shall be turned off. Deck lights, interior lights, and lights used during navigation could remain on for safety.[1]
- All bird collisions (with vessels and aircraft) shall be documented and reported within 3 days to MMS. Minimum information shall include species, date/time, location, weather, identification of the vessel or aircraft involved and its operational status when the strike occurred. Bird photographs are not required, but would be helpful in verifying species. Permittees/operators are advised that the FWS does not recommend recovery or transport of dead or injured birds due to avian influenza concerns.

The following monitoring and mitigation measures are related to the requirements of the MMPA and ESA. However, final mitigation and monitoring requirements defined in any NMFS (the Federal agency having MMPA management authority for cetaceans and pinnipeds, less Pacific walrus) and FWS (the Federal agency in having MMPA management authority for Pacific walrus, polar bear, and sea otter) ITA and/or Letters of Authorization (LOA) obtained by the seismic survey operator will have precedence over any related measures listed below:

- **Exclusion Zone** – A 180/190 dB isopleth exclusion zone from the seismic-survey sound source shall be free of marine mammals before the survey can begin and must remain free of marine mammals during the survey. The purpose of the exclusion zone is to protect marine mammals from Level A harassment (injury).The 180 dB applies to cetaceans and the Pacific walrus, and the 190 dB applies to pinnipeds other than the Pacific walrus. The exclusion zones specified in ITAs and/or LOAs will take precedence over the MMS-identified exclusion zones.
- **Monitoring of the Exclusion Zone** – Individuals (marine mammal biologists or trained observers) shall monitor the area around the survey for the presence of marine mammals to maintain a marine mammal-free exclusion zone and monitor for avoidance or take behaviors. Visual observers monitor the exclusion zone to ensure that marine mammals do not enter the exclusion zone for at least 30 minutes prior to ramp up, during the conduct of the survey, or before resuming seismic-survey work after shut down. The NMFS will set specific requirements for the marine mammal monitoring program and observers.

[1] Nothing in this mitigation measure is intended to reduce personnel safety or prevent compliance with other regulatory requirements (e.g., U.S. Coast Guard or Occupational Safety and Health Administration) for marking or lighting of equipment and work areas.

- **Shut Down/Power Down** – A seismic survey shall be suspended until the exclusion zone is free of marine mammals. All observers shall have the authority to, and will, instruct the vessel operators to immediately stop or de-energize the airgun array whenever a marine mammal is seen within the exclusion zone or to power down to a sound level where the marine mammal in no longer in the exclusion zone. If the airgun array is completely powered down for any reason during nighttime or poor sighting conditions, it shall not be re-energized until daylight or whenever sighting conditions allow for the exclusion zone to be effectively monitored from the source vessel and/or through other passive acoustic, aerial, or vessel-based monitoring.
- **Ramp Up** – Ramp up is the gradual introduction of sound to deter marine mammals from potentially damaging sound intensities and from approaching the exclusion zone. This technique involves the gradual increase (usually 5-6 dB per 5-minute increment) in emitted sound levels, beginning with firing a single airgun and gradually adding airguns over a period of 20-to-40 minutes, until the desired operating level of the full array is obtained. Ramp-up procedures may begin after observers ensure the absence of marine mammals for at least 30 minutes. Ramp-up procedures shall not be initiated when monitoring the exclusion zone is not possible. A single airgun operating at a minimum source level can be maintained for routine activities, such as making a turn between line transects, for maintenance needs or during periods of impaired visibility (e.g., darkness, fog, high sea states), and does not require a 30-minute clearance of the exclusion zone before the airgun array is again ramped up to full output.
- **Field Verification** – Before conducting the survey, the operator shall verify the radii of the exclusion zones within real-time conditions in the field. This provides for more accurate exclusion-zone radii rather than solely relying on modeling techniques before entering the field. When moving a seismic-survey operation into a new area, the operator shall verify the new radii of the exclusion zones by applying a sound-propagation series.
- **Reporting Requirements** – Operators must report immediately any shut downs/power downs due to a marine mammal entering the exclusion zones and provide the regulating agencies and MMS with information on the frequency of occurrence and the types and behaviors of marine mammals (if possible to ascertain) entering the exclusion zones.
- **Spring Lead System** – In order to provide bowhead whale and walrus cow/calf pairs additional protection, and unless authorized under the MMPA by NMFS and FWS, seismic surveys shall not occur in the Chukchi Sea spring lead system – as defined by NMFS – before July 1.
- **Ledyard Bay Critical Habitat Unit (Unit)** – Except for emergencies or human/navigation safety, surface vessels associated with seismic survey operations shall avoid travel within the Unit between July 1 and November 15. To the maximum extent practicable, aircraft supporting seismic survey operations shall avoid operating below 1,500 feet ASL over the Unit between July 1 and November 15. Vessel travel within the Unit and altitude deviations by aircraft over the Unit for emergencies or human safety shall be reported within 24 hours to MMS.
- **Walrus-** Vessels and aircraft should avoid concentrations or groups of walruses. Operators should, at all times, conduct their activities at a maximum distance from such aggregations. Seismic-survey and associated support vessels shall observe a 0.5-mile safety radius around Pacific walrus groups hauled out onto land or ice. Under no circumstances, other than an emergency, should aircraft be operated at an altitude lower than 1,500 feet ASL when within 0.5-mile of walrus groups. Helicopters may not hover or circle above such areas or within 2,500 lateral feet of such areas.
- **Polar Bear –** Seismic survey operators shall adhere to any mitigation measures identified by the FWS to protect polar bears from being harassed and/or injured.

The following mitigation measures may reduce further the potential for adverse environmental impacts. The specific measures identified in NMFS and FWS ITA's will apply, where applicable, including protocols for monitoring programs.

- A 120-dB monitoring (safety) zone for bowhead whales in the **Beaufort Sea** will be established and monitored, once 4 or more bowhead whale cow/calf pairs are observed at the surface during an aerial monitoring program within the area to be seismically surveyed during the next 24 hours. No seismic surveying shall occur within the 120-dB safety zone around the area where the whales were observed until two consecutive surveys (aerial or vessel) indicate they are no longer present within the 120-dB safety zone of seismic surveying operations.
- A 120-dB aerial monitoring zone for bowhead whales in the **Chukchi Sea** will be established and monitored: (1) once 4 or more migrating bowhead whale cow/calf pairs are observed at the surface during the vessel research monitoring program; (2) once Barrow whalers notify NMFS or MMS that bowhead whale cow/calf pairs are passing Barrow, or (3) on September 25th, whichever is earliest. Once notified by NMFS or MMS, a daily aerial survey will occur (weather permitting) within the area to be seismically surveyed during the next 24 hours. Whenever 4 or more migrating bowhead whale cow/calf pairs are observed at the surface during an aerial monitoring program, no seismic surveying shall occur within the 120-dB monitoring zone around the area where the whales were observed by aircraft until two consecutive surveys (aerial or vessel) indicate they are no longer present within the 120-dB safety zone of seismic surveying operations.
- A 160-dB vessel monitoring zone for bowhead and gray whales will be established and monitored in the **Chukchi Sea** during all seismic surveys. Whenever an aggregation of bowhead whales or gray whales (12 or more whales of any age/sex class that appear to be engaged in a non-migratory, significant biological behavior (e.g. feeding, socializing) are observed during an aerial or vessel monitoring program within the 160-dB safety zone around the seismic activity, the seismic operation will not commence or will shut down immediately until two consecutive surveys indicate such whales are no longer present within the 160-dB safety zone of the seismic-surveying operations.
- Dedicated aerial and/or vessel surveys, if determined by NMFS to be appropriate and necessary, shall be conducted in the **Beaufort and Chukchi seas**, during the fall bowhead whale-migration period to detect bowhead whale cow/calf pairs, and to detect aggregations of feeding bowhead and gray whales. The protocols for these aerial and vessel monitoring programs will be specified in the MMPA authorizations granted by NMFS.
- Survey information, especially information about bowhead whale cow/calf pairs or feeding bowhead or gray whales, shall be provided to NMFS as required in ITA's and will form the basis for NMFS determining whether additional mitigating measures, if any, will be required over a given time period.
- To avoid significant additive and synergistic effects from simultaneous seismic-survey operations that might hinder the migration of bowhead whales, NMFS and MMS will review the seismic-survey plans and may require special restrictions, such as additional temporal or spatial separations.