Part One

Prudent Development

Part One

Overview and Key Findings

INTRODUCTION

The Arctic can be defined as areas north of the Arctic Circle, as shown in the figure below. The United States (Alaska), Canada, Russia, Kingdom of Denmark (via Greenland), and Norway all have coastlines within this region. The Arctic is a unique environment, often distinguished by the presence and type of ice and its general remoteness. Polar nights bring periods of up to 24 hours of darkness during the winter months and year-round ambient temperatures are generally low and mostly well below freezing. The physical environment varies widely from country to country, basin to basin, and even year

Arctic Circumpolar Map Highlighting the Arctic Circle in Orange and Key Regions and Sea Routes to year. There are three key characteristics in the Arctic that significantly impact the technology required, the choice of facilities, the complexity of operations, and the economics of exploration and development of oil and gas resources—ice type and abundance, water depth, and length of open water season. The predominant characteristic is ice type and abundance. Water depth and length of open water season also play important roles in differentiating one Arctic location from another.

This report is organized around three key themes (parts) and has 10 chapters:

Part One: Prudent Development

Overview and Key Findings

1. Arctic Resource Potential and History of Operations
2. Development Potential and Challenges
3. Implementation of U.S. Strategy for the Arctic Region
4. Policy and Regulatory Opportunities to Promote Prudent Development

Part Two: Technology and Operations

Overview

5. Characterization and Measurement of the Ice Environment
6. Offshore Arctic Exploration and Development Technologies
7. Logistics and Infrastructure
8. Arctic Offshore Oil Spill Prevention, Control, and Response

Part Three: Ecological and Human Environment

Overview

9. The Ecological Environment
10. The Human Environment

The National Petroleum Council (NPC) is tasked with providing input on the research that the Department of Energy should pursue and the technology constraints that must be addressed to ensure prudent development of Arctic oil and gas resources while advancing U.S. energy and economic security and ensuring environmental stewardship. While discussion is provided on many onshore and subarctic locations to provide global context, the focus of this NPC Arctic research study is on the U.S. Arctic offshore. This includes both Alaskan state waters (nearshore) and federal waters, also known as the OCS (Outer Continental Shelf). Hereafter, this may be simply referred to as "the study area." As discussed in all chapters, the technology to prudently explore and develop most of the U.S. Arctic is available today; however, there are several opportunities for research and several policy considerations that could enhance prudent exploration and development.

The first theme, and the focus of the first four chapters, is prudent development in the Arctic. The scope of these chapters is broad, beginning with the global context on Arctic resource potential and the history of exploration and development in Chapter 1. Chapter 2 discusses the Arctic environment and exploration and development potential and challenges. Chapter 3 provides insight on the U.S. National Strategy for the Arctic. The prudent development theme concludes with Chapter 4, which outlines policy and regulatory barriers, other than research and technology, that are currently limiting large-scale offshore exploration and development in U.S. Arctic waters, and makes actionable recommendations to address these barriers. The prudent development theme provides the necessary foundation for the more forward-looking Arctic technology and operations chapters, which focus on research that could potentially promote prudent development in the Arctic.

In the NPC's 2011 report *Prudent Development: Realizing the Potential of North America's Abundant Natural Gas and Oil Resources*, the term "prudent development" was used as one of the key concepts for developing policy recommendations for harnessing North America's emerging petroleum renaissance. In his study request, "prudent development" was used by then-Energy Secretary Steven Chu; he called for "advice on policy options that would allow prudent development of North American natural gas and oil resources."

The NPC defined prudent development in its report as "Development, operations, and delivery systems that achieve a broadly acceptable balance of several factors: economic growth, environmental stewardship and sustainability, energy security, and human health and safety.… [P]rudent development necessarily involves trade-offs among these factors. Consideration of the distribution costs and benefits is a key part of prudent development." This same definition is used as a lens for evaluating and making recommendations in this current report on developing Arctic resources.

The NPC recognizes that it is the responsibility of both industry and the government to work together with stakeholders in developing resources prudently in this important and unique area of the world. To address the factors of prudent development and other challenges, the analysis and recommendations in the first four chapters will cover the activities associated with prudent development—that is, finding, developing, producing, and transporting these resources to markets. It is also recognized that technology employment is inextricably linked to the policy and regulatory requirements, and that international as well as U.S. government and industry cooperation and advocacy will be required to address these challenges constructively and proactively. Furthermore, although not discussed in detail until later chapters, respect for Arctic indigenous populations and increasing an already-broad understanding of the various Arctic ecosystems and human environment will be integral to prudent development.

In issuing the administration's National Strategy for the Arctic Region (NSAR) in May 2013, President Barack Obama stated:

> Through the National Strategy for the Arctic Region, we articulate our strategic priorities to position the United States to meet the challenges and opportunities that lie ahead. We will seek to prioritize and effectively integrate the work of federal departments and agencies with activities that are already underway in the State of Alaska and at the international level. And we will partner with the State of Alaska and Alaska Natives, as well as the international community and the private sector, to develop innovative solutions and new ways of operating.

Responsibly developing Arctic oil and gas resources to ensure energy security is a key aspect of the U.S. NSAR and, in consideration of the U.S. government's Implementation Plan for the NSAR, Chapter 3 provides context on how elements of this strategy might be implemented.

Arctic resource potential is expected to be significant and there is a high potential for large oil and gas accumulations. However, resource potential estimates are inherently uncertain given the methods used for their estimation and the fact that many accumulations are yet to be drilled or produced. Despite the anticipated potential, the economic viability of any accumulations is yet to be determined and depends on many factors. To date, petroleum activities in the global Arctic have resulted in the production of over 25 billion barrels of liquids[a] and 550 trillion cubic feet of natural gas.[b] Additionally, a reserves base of 38 billion barrels of liquids and 920 trillion cubic feet of natural gas is estimated. The Arctic is also estimated to contain an additional 525 BBOE[c] of resource potential, 426 BBOE of which is undiscovered conventional liquids and gas. This 426 BBOE represents 25% of the global undiscovered conventional resource potential. The majority of the Arctic resource potential is expected to be gas and offshore, with most of the U.S. offshore potential in water depths less than 100 meters. While Russia is estimated to have by far the largest Arctic resource potential and will continue to be a dominant player in Arctic oil and gas development, the future development of U.S. Arctic resources can play an important role in U.S. national, energy, and economic security. Furthermore, development of U.S. Arctic resources can help maintain the long-term viability of the Trans-Alaska Pipeline System (TAPS), a strategic asset for energy security that provides financial benefits to federal, state, and local entities.

Projections in the U.S. Energy Information Administration's *Annual Energy Outlook 2014* indicate that U.S. energy consumption will increase by about 0.4% per year through 2040. Growing domestic production of oil and natural gas continues to reshape the U.S. energy economy, largely as a result of rising production from shale and tight oil. However, the effect could vary substantially depending on expectations about resources and continued technology enhancements to ensure the United States remains competitive in the global Arctic. Higher oil and natural gas production could spur even more industrial growth and lower the use of imported petroleum. Also, the shift away from the more carbon-intensive

a Liquids include oil and natural gas liquids.

b IHS, International E&P Database (online), September 3, 2014.

c Billion barrels of oil, or oil equivalent for gas; 6,000 cubic feet of gas is equivalent to one barrel of oil.

coal for electricity generation to reduce the U.S. energy-related carbon dioxide (CO_2) emissions provides additional interest in developing the oil and natural gas resources in the United States. The cycle of leasing, exploration, discovery, appraisal, and development takes longer in the Arctic than in other offshore regions because of remote and ice-prone conditions, long supply chains, the need for environmental stewardship and sustainability, and a need for active and continuous dialogue with many stakeholders. Considering, the time frame for developing any significant drilling activity over the next 15 years or so, offshore Alaska could reasonably be expected to yield material new production by the early 2030s and sustain this level of production through mid-century and beyond. Given these lengthy lead times, timely exploration of the U.S. offshore Arctic resources will be required now to support U.S. Energy security in the medium to long term.

Key Findings of Part One: Prudent Development

The key findings of the first four chapters are relatively consistent with and respectively build upon the findings and conclusions from previous related NPC reports. The NPC reports *U.S. Arctic Oil and Gas* (1981) and *Prudent Development* (2011), both highlighted several findings and recommendations related to U.S. Arctic development that are consistent with the findings of this study. Three examples are listed below.

- There is a significant resource base within North America that could help the United States reduce its reliance on imported oil.
- Effective regulation and a commitment by industry and regulators to continually improve practices are required.
- Lease terms in the Arctic are not commensurate with the challenges faced in the Arctic relative to other areas of oil and gas exploration and development.

The following are the key findings of the four prudent development chapters.

- Arctic oil and gas resources are estimated to be large and can contribute significantly to meeting future U.S. and global energy needs.
  - The global Arctic has 525 BBOE of resource potential with 70% (372 BBOE) expected to be gas. The United States (Alaska) has approximately 20% of the Arctic conventional resource potential. Alaska and Russia both contain the largest estimate of undiscovered conventional oil in the Arctic.
  - Globally, 75% (389 BBOE) of the Arctic resource potential is expected to be offshore.
  - The majority of Alaska's offshore undiscovered conventional volumes are in the Chukchi and Beaufort OCS.
- The petroleum industry has a long history of successful operations in Arctic conditions enabled by continuing technology and operational advances.
  - Successful exploration and selective development has been demonstrated globally in onshore and offshore Arctic and subarctic locations such as Cook Inlet, U.S. and Canadian Beaufort Seas, Chukchi Sea, offshore Newfoundland, South Barents Sea, Sea of Okhotsk, and many other areas over the past 50 years or more.
  - Most of the U.S. Arctic offshore conventional oil resources are in less than 100 meters of water and can be developed using existing field-proven technology.
- The Arctic environment poses some different challenges relative to other petroleum production areas.
  - There is not one Arctic physical environment. Water depth, ice presence and type, meteorological and oceanographic conditions, and open water seasons vary from country to country, basin to basin, and year to year.
- The economic viability of Alaskan Arctic development is challenged.
  - A discovery of material size and quality is needed to justify the significant investment necessary for development, including required infrastructure.
  - Exploration and development timelines are long and costs are high in the Arctic relative to other oil and gas production areas given the general remoteness, presence of ice, and lack of infrastructure.
  - The offshore drilling season length can be safely extended into the ice season through use of available technologies to enable more cost-effective prudent exploration and development.

- The scope of work (exploration, appraisal, and potential commitment to produce) required to be completed during the lease term, for both onshore and offshore in the U.S. Arctic, is not commensurate with the current 10-year lease period, especially when one considers the limited operating window available compared to conventional areas in the Lower 48.

- Realizing the promise of Arctic oil and gas requires securing public confidence.
  - Prudent development is the development, operations, and delivery systems that achieve a broadly acceptable balance of several factors: economic growth, environmental stewardship and sustainability, energy security, and human health and safety.
  - Industry must operate responsibly, bringing appropriate technology and operating practices to bear and continuously improving technologies and operations.
  - Government must establish high-level policy and ensure alignment and consistency among agencies in promoting those policies and develop and maintain regulatory processes that provide for safe and effective operations.
  - Both industry and government must engage the local community.

- There is a long history of U.S. Arctic strategy and policy.
  - Cooperation, coordination, and prioritization of U.S. initiatives will be required to constructively and proactively execute the Implementation Plan for the National Strategy for the Arctic region and support additional Arctic Council programs.
  - The U.S. has the opportunity to use its upcoming chairmanship of the Arctic Council to promote, sustain, and encourage scientific research and collaboration and to also use the Arctic Economic Council's business advisory role as a way to improve the economic and living conditions of the people of the North.

- The oil and gas industry in the Arctic is well regulated.
  - The opportunity exists to move toward a more performance-based regulatory system to encourage the use of available technology and future innovation.
  - Coordination of Arctic regulation and timely permitting could be improved.

Chapter 1

Arctic Resource Potential and History of Operations

ARCTIC RESOURCE POTENTIAL

Scope

This section of the chapter discusses the resource potential in the Arctic, in areas traditionally defined as north of the Arctic Circle (i.e., north of the 66.56° latitude line). The focus is on the volume of petroleum resource remaining in the Arctic assessed to be technically recoverable over the next 50 years and does not consider commerciality. For context, a description of the primary data sources and data variability is provided. Volumes are presented in categories including total resource, the portion discovered that is undeveloped, and undiscovered, as well as splits between oil, gas, and natural gas liquids (NGLs), and by water depth. The focus is on conventional resources given the global data available. Unconventional resource data has also been included for Alaska where available. The collective Arctic region is summarized, with subsequent details provided on the five countries that have coastlines within the Arctic: United States, Canada, Russia, Kingdom of Denmark (via Greenland), and Norway.

Introduction

Estimates of Arctic resource potential are significant but can be highly variable given the limited amount of data available in many areas. The Arctic may be the largest geographically unexplored area for prospective petroleum remaining in the world. The Arctic Circle encompasses 21 million square kilometers (sq. km) (6% of the world's surface area) split 40% onshore and 60% offshore. Most of the exploration to date has been onshore with the majority of the offshore region still unexplored. Approximately 10% of the world's known conventional petroleum resource has been discovered in the onshore Arctic over the past 50 years, offering insight into the region's significant resource potential.[1] Probabilistic methodology of geological analysis and analog modeling has been used by the United States Geological Survey (USGS) and others to estimate resource potential. Estimates for the Arctic continue to be revised and updated, particularly as exploration and production data become available, and consistently show large volumes of recoverable oil and gas remaining in the region—approximately 25% of the world's remaining undiscovered conventional petroleum resource.[2,3]

The resource potential discussed in this section is limited to technically recoverable volumes and does not consider commerciality. The focus of near-term and long-term strategies to address technology, regulatory, and environmental challenges of developing the Arctic will be based heavily on the size, type, and location of the remaining resources. For example, exploration and development plans must consider whether the resource is oil versus gas, located onshore versus offshore, in shallow versus deep water, or located in the United States versus other countries in the Arctic. As a result, characterizing the resource potential becomes as important as quantifying it since the resource characteristics will determine exploration and development plans.

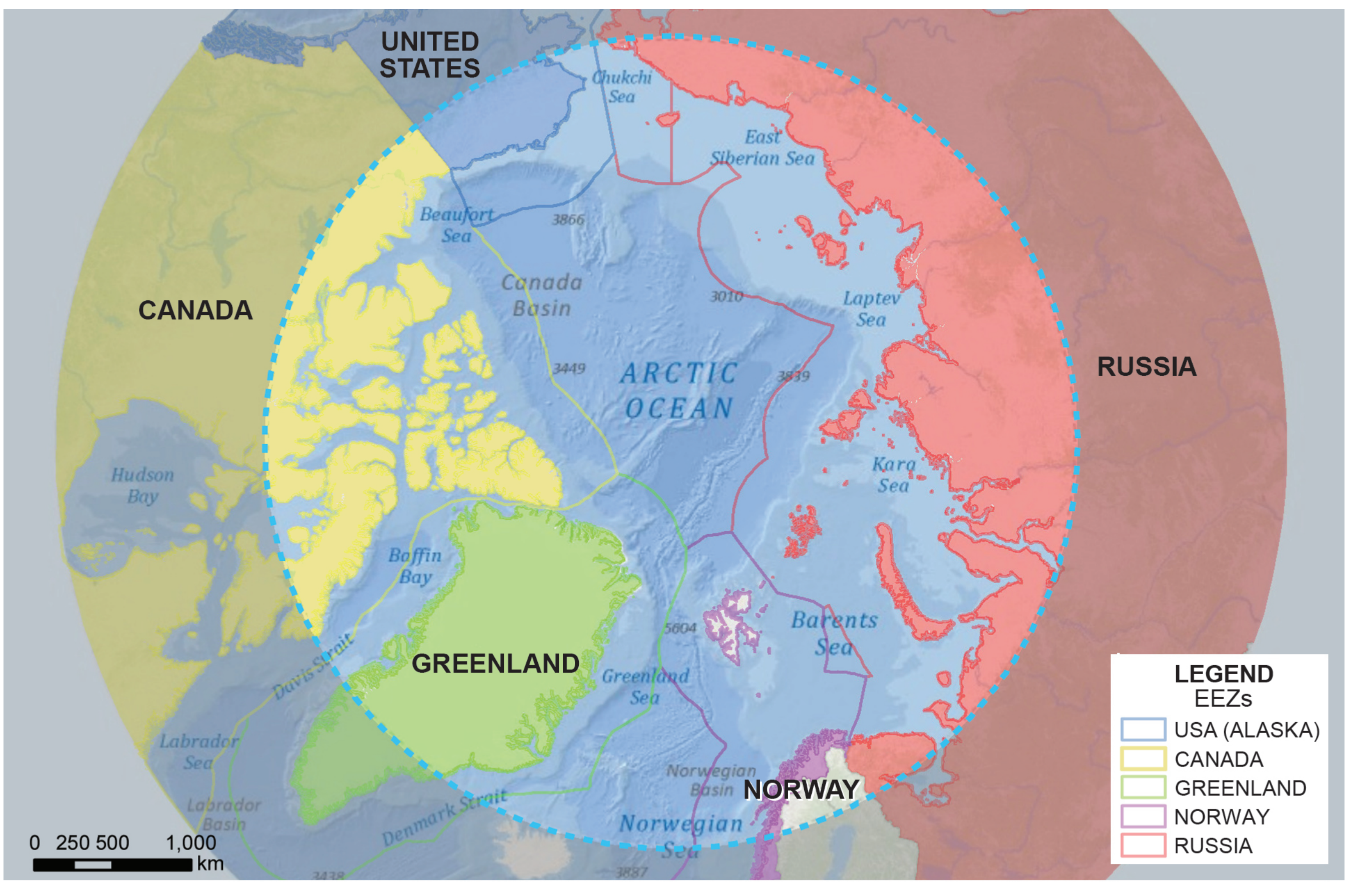
Defining Resource Potential within the Arctic

In this section, resource potential is defined as *discovered contingent petroleum resources, plus mean, risked, technically recoverable, undiscovered petroleum resources*. Cumulative Arctic production and current reserves are also provided to provide context for the resource potential discussion.

Discovered contingent resources are quantities of petroleum estimated, as of a given date, to be technically recoverable from known accumulations without consideration of commercial viability. Reserves are quantities of discovered resources anticipated to be commercially recoverable from a given date forward by application of development projects under assumed economic conditions, operating practices, and government regulations. Reserves must be discovered, technically recoverable, commercial, and remaining based on the development project(s) applied.

Undiscovered resources are believed to exist outside of known accumulations on the basis of geologic studies and represent the technically recoverable portion of the in-place oil and gas endowment. As these volumes have not yet been discovered, they are calculated based on the probability of occurrence (i.e., risked).

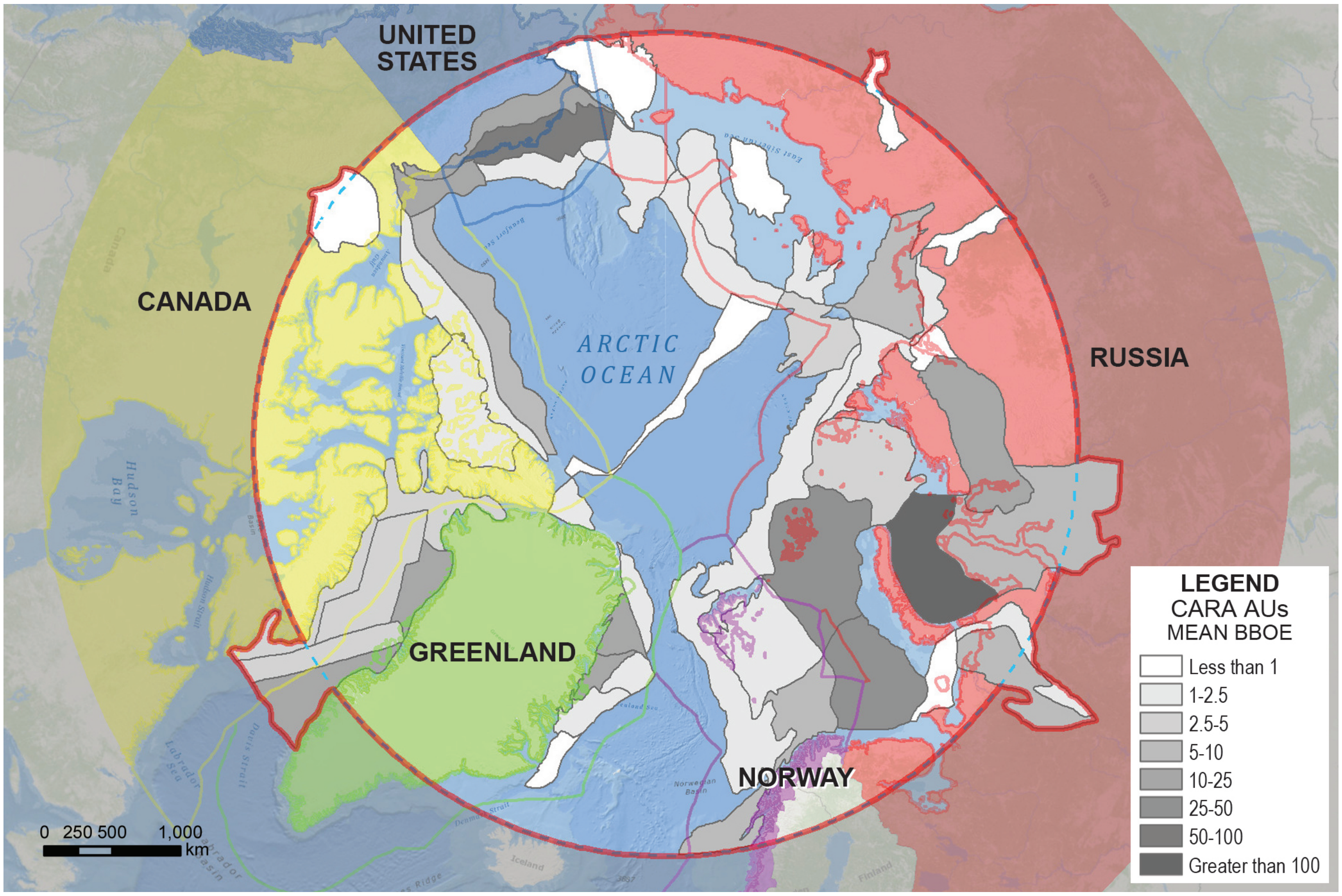
The resource potential discussed in this section is confined to the Arctic. The Arctic has traditionally been defined as areas north of the Arctic Circle, that is, the 66.56° north latitude line as shown in Figure 1-1. Five countries have coastlines within this region: the United States, Canada, Russia, Kingdom of Denmark (via Greenland), and Norway. The resource potential discussed is exclusive to these countries but, for practical purposes, is not limited to regions strictly north of the Arctic Circle. Several of the prospective basins are partially south of the Arctic Circle and have volumes that will require considerations for prudent development similar to their northern counterpart, as shown in Figure 1-2. As per USGS methodology, the prospective basins included in the estimates have a 10% chance of one or more accumulations containing recoverable volumes of at least 50 million barrels of oil equivalent (MMBOE).[4] (Note: A barrel of oil equivalent [BOE] is used to quote gas volumes in



Note: These boundaries are intended for illustrative purposes only and were used in this report to calculate and illustrate the approximate volumes in a given basin allocated to a particular country.

Source for EEZ Boundaries: VLIZ (2009). Maritime Boundaries Geodatabase, version 5, http://www.vliz.be/vmdcdata/marbound.

Figure 1-1. *Map of the Arctic Countries Highlighting Their Exclusive Economic Zones (EEZs)*



Note: CARA AUs – Circum-Arctic Resource Appraisal Assessment Units.
Source for Hydrocarbon Data: C. Schenk, *An Estimate of Undiscovered Conventional Oil and Gas Resources of the World*, USGS, Denver, 2012.

Figure 1-2. *Arctic Study Area Showing Estimated Relative Resource Density by Basin*

equivalent oil barrels; 6,000 cubic feet of gas equals 1 BOE and is used in this chapter.)

Focus is given to conventional petroleum resources, but, where possible, unconventional resources are discussed. For example, shale oil and gas and coalbed methane are included in the assessment, but gas hydrates are excluded because this type of resource is currently not considered developable.[5] Additional research and technology development will be required to produce natural gas from gas hydrates in the future.

Methodology and Assumptions

No new assessment was performed to estimate resource potential for the exclusive purpose of this report. Instead, existing studies and publicly available databases were leveraged to source relevant, credible and reliable data. The main data types that are used to define resource potential and their primary source are as follows:

- **Undiscovered Conventional Resource Potential Estimates** were provided by the USGS, based on their 2008 Circum-Arctic Resource Appraisal (CARA).[6,7] The CARA involved defining prospective basins (termed assessment units or areas), mappable volumes of rock with common geologic traits, and used probabilistic methodology and analog modeling to quantitatively assess these assessment units for petroleum potential. Using a global database of known reserves and types in various geologic formations, comprehensive estimates for the circum-arctic were generated. However, they excluded assessment units that were assessed to have less than 10% chance of one or more accumulations containing recoverable volumes of at least 50 MMBOE and only considered conventional petroleum resources.

One of this report's objectives is to summarize the undiscovered resource potential in the five Arctic nations. In the CARA, assessment areas were based on analog basins that typically do not have uniform field densities (number of accumulations per unit area). However, for simplicity, it is assumed in this section that the mean risked resource estimated for an assessment unit is evenly distributed and correlates directly to the assessment area's geographic area. The ratio of an assessment area's resource allocated to a given country is assumed to be equal to the ratio of the assessment area's area that falls within that country's exclusive economic zone. The only exception to this is if the assessment area extends into international territory, in which case that portion is allocated among the nations that share the assessment area. A similar methodology was used in determining the resource potential distribution by water depth.

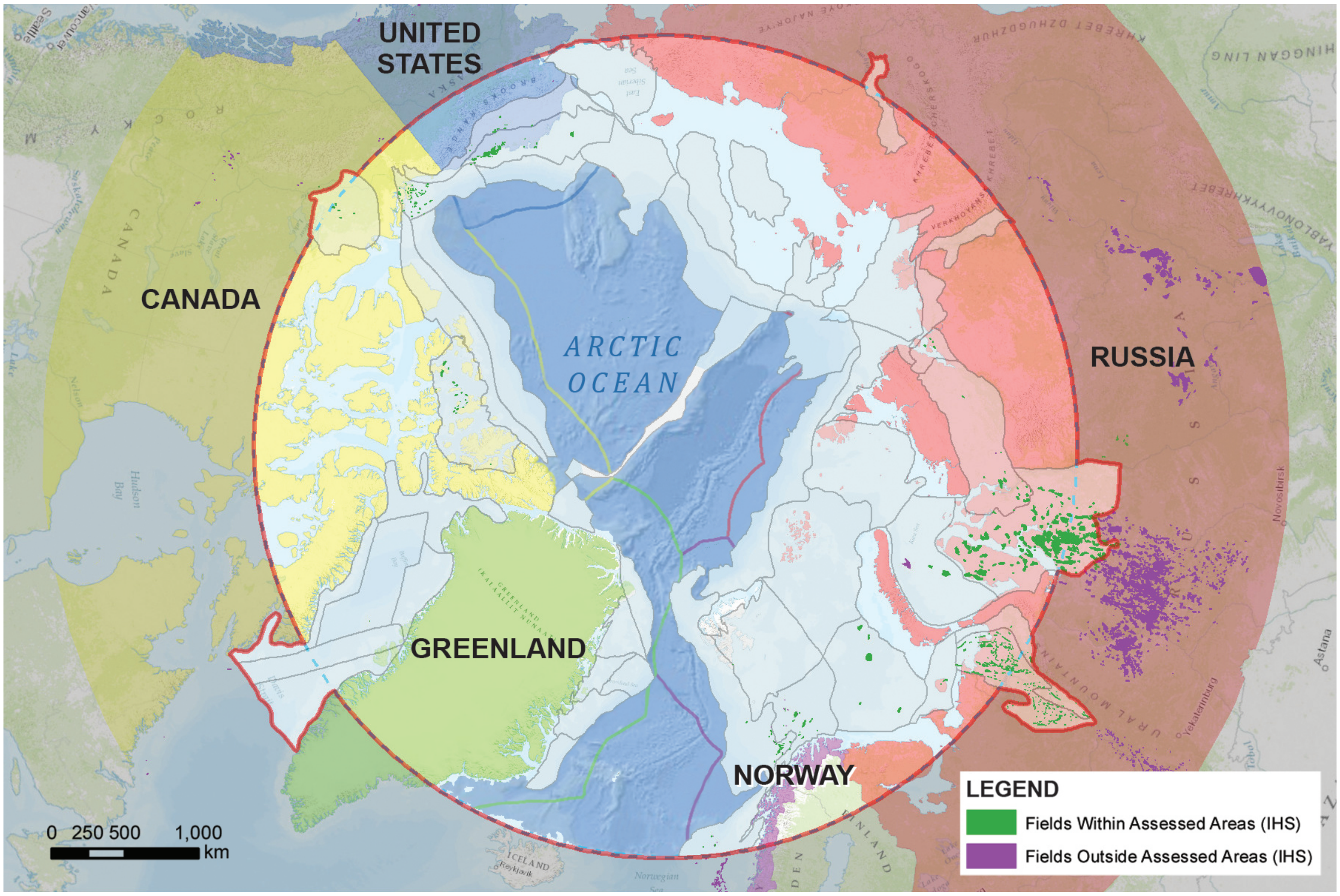
- **Estimates for Alaska** are based on USGS fact sheets for onshore and state waters and Bureau of Offshore Energy Management (BOEM) fact sheets for the Outer Continental Shelf (OCS).[8,9,10,11,12,13] These estimates compare well, but do not match exactly, to the estimates generated for the United States (Alaska) using the CARA method previously discussed. For consistency, estimates from the CARA method are referenced when comparing resource potential by country, and the USGS and BOEM estimates are referenced for the detailed Alaska discussion.

- **Undiscovered Unconventional Resource Potential Estimates** are sourced from the USGS fact sheets for shale oil and gas and coalbed methane on the Alaska North Slope.[14,15] The USGS has also published estimates for heavy oil and natural bitumen in terms of oil in place (approximately 9 trillion barrels of oil globally), but no assessment of how much is technically recoverable has been published to date.[16] For this reason, resource potential estimates for heavy oil have not been included in this report. Resource potential estimates for gas hydrates have also been published by the USGS[17] but, as previously mentioned, production of natural gas from gas hydrates is considered to require additional research and technology development, preventing these volumes from being categorized as resource potential as defined in this section, given the timeframe of this study. Several studies are ongoing to assess Arctic unconventional resources, which are believed to be quite significant even when compared to conventional resources. However, due to a lack of publicly available data, this report's discussion on unconventional resource potential is limited to Alaska.

- **Discovered Resource Potential Estimates** are based on international exploration and production data from IHS Inc., as reported by governments or operating companies as of September 2014.[18] The IHS database includes cumulative production, resource in place, and resource recoverable for discovered reservoirs and fields globally, as shown in Figure 1-3. The discovered resource potential is based on the IHS recoverable resource estimate from reservoirs or fields that are undeveloped and are not currently being developed (i.e., a project final investment decision has yet to be made). These volumes may also be considered contingent resources. Cumulative production and current reserves, which are referenced in this section, were also sourced from IHS. Reserves were calculated as the recoverable volumes from producing and developing fields excluding volumes already produced. The only exception to this is for Alaska, where recoverable gas volumes from producing and developing fields are categorized in this section as discovered contingent due to the lack of gas export infrastructure.

Variability of Resource Potential Estimates

A high degree of uncertainty is associated with estimates for undiscovered resources, particularly for less developed regions like the Arctic. All resource estimates are generated based on an underlying set of assumptions and modeling techniques, which usually employ analogs and statistical analyses. Understanding these assumptions and techniques is an important part of properly interpreting the results. For example, the undiscovered resource potential of the Arctic described in this section is the sum of mean estimates from the CARA study, but the range of estimates is relatively large. The CARA gives a low side estimate of 44 billion barrels of oil (BBO) and 770 trillion cubic feet (TCF) of gas, and a high side estimate of 157 BBO and 2,990 TCF of gas. These ranges represent an aggregation of the estimate distribution in all the assessment areas, though it must be noted that areas with discovered and producing fields, such as those in Alaska, will have lower



Source for Fields Data: IHS, International E&P Database (online), September 3, 2014.

Figure 1-3. *Map of Petroleum Discoveries in the Arctic Highlighting in Green Those Fields That Fall within the Study Area*

uncertainty in the estimates than areas with no discoveries, such as those in Greenland. Despite the uncertainty of the CARA, it provides the most comprehensive and consistent assessment of undiscovered conventional resource potential throughout the Arctic and remains one of the most widely referenced and recognized public sources.

Several other institutions have published estimates of resource potential for various Arctic areas. It is important to recognize that scope, technical assumptions, and definition of resource potential are likely to vary even for assessments with similar objectives when performed by different parties. The results of other studies often vary significantly for similar regions in the Arctic. Following are examples of how resource potential estimates, including technically recoverable resources, from other sources differ from the primary sources used in this section.

- **Canadian Arctic (2013):** The National Energy Board estimates Northern Canada to have 12 BBO and 116 TCF of natural gas in resource potential.[19] By comparison, the resource potential cited for the Canadian Arctic in this section is 15 BBO and 112 TCF of natural gas.

- **Russian Arctic Offshore (2012):** The Russian government estimates a total of 471 billion barrels of oil equivalent (BBOE) comprising of 64 BBO in the Russian Arctic.[20] A smaller estimate is cited in this section for the same area; 315 BBOE, comprising 36 BBO (65 billion barrels if NGLs are included).

- **Norwegian Barents Sea (2013):** The Norwegian Petroleum Directorate estimates 4 BBO and 30 TCF of natural gas in the Norwegian Barents Sea.[21] This compares to the higher estimate of 4 BBO and 93 TCF of gas for the Norwegian Barents included in Norway's total resource potential in this section.

Global Arctic Summary

Petroleum activities in the Arctic have resulted in the production of over 23 billion barrels of crude oil and 550 TCF of natural gas.[22] Almost 30 billion barrels of crude oil and 920 TCF of natural gas are also estimated in reserves.[23] Most of the Arctic petroleum, however, has yet to be developed or even discovered; these make up the resource potential, which is estimated to be over 60% of the Arctic's petroleum as shown in Figure 1-4.

Table 1-1 summarizes the resource potential for the global Arctic, split by discovered and undiscovered, offshore, onshore, by type, and by country.

The Arctic is estimated to have 525 BBOE of resource potential. Of this, 426 BBOE is undiscovered, as shown in Figure 1-5, which represents 25% of the world's undiscovered conventional resource potential.[24] The total Arctic resource potential includes 106 billion barrels of crude oil, 2,232 TCF of natural gas, and 47 billion barrels of natural gas liquids, distributed among five countries.

Natural gas alone makes up over 70% of the total Arctic resource potential in oil equivalent barrels as shown in Figure 1-6. Such an abundance of natural gas is an indication of the Arctic's potential to provide the world with long-term sustained energy

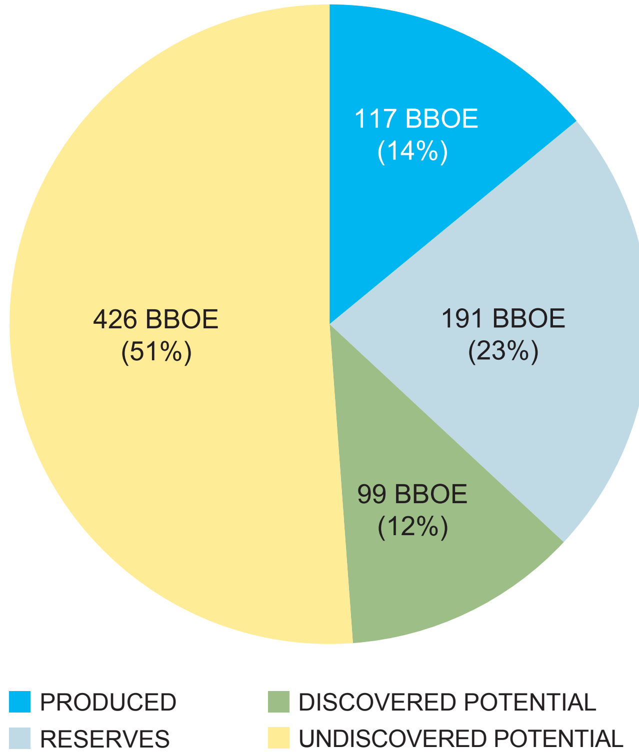


Figure 1-4. *Global Arctic Conventional Endowment: Total Produced to Date, Current Reserves, and Estimated Resource Potential*

Resource Type		United States		Canada		Russia		Greenland		Norway		Total
		Onshore	*Offshore*	*Onshore*	*Offshore*	*Onshore*	*Offshore*	*Onshore*	*Offshore*	*Onshore*	*Offshore*	
Oil (BBO)	Undiscovered	9.9	21.9	1.4	11.3	12.6	17.9	0.8	15.3	0.1	4.5	96
	Discovered	1.4	0.7	0.4	1.5	4.6	0.5	0.0	0.0	0.0	0.9	10
Total Oil (BBO)		**11.3**	**22.6**	**1.8**	**12.8**	**17.2**	**18.4**	**0.8**	**15.3**	**0.1**	**5.4**	**106**
Natural Gas (TCF)	Undiscovered	91.3	138.8	11.9	76.5	166.2	977.8	6.2	129.9	1.2	112.2	1,712
	Discovered	99.7	28.1	12.3	11.1	183.7	177.4	0.0	0.0	0.0	7.9	520
Total Gas (TCF)		**191.0**	**166.8**	**24.2**	**87.5**	**349.9**	**1,155.3**	**6.2**	**129.9**	**1.2**	**120.1**	**2,232**
NGLs (BBNGL)	Undiscovered	2.4	3.4	0.2	1.3	4.4	23.1	0.4	8.8	0.0	1.0	45
	Discovered	0.0	0.7	0.0	0.0	1.0	0.5	0.0	0.0	0.0	0.1	2
Total NGLs (BBNGL)		**2.4**	**4.1**	**0.2**	**1.3**	**5.4**	**23.6**	**0.4**	**8.8**	**0.0**	**0.0**	**47**
Total Resource (BBOE)	Undiscovered	27.5	48.4	3.7	25.3	44.7	203.9	2.2	45.8	0.3	24.2	426
	Discovered	18.1	6.1	2.4	3.3	36.2	30.6	0.0	0.0	0.0	2.3	99
Total Resource (BBOE)		**45.6**	**54.5**	**6.1**	**28.7**	**80.9**	**234.6**	**2.2**	**45.8**	**0.3**	**25.4**	**525**

Note: Oil in billion barrels (BBO), natural gas in trillion cubic feet (TCF), NGLs in billion barrels (BBNGL) and total resource potential in billion barrels of oil equivalent (BBOE).

Sources: D. Gautier, Chapter 9: Oil and Gas Resource Potential North of the Arctic Circle (originally published by The Geological Society of London), USGS, Menlo Park, 2011; and IHS, International E&P Database (online), September 3, 2014.

Table 1-1. *Summary of Global Arctic Conventional Resource Potential*

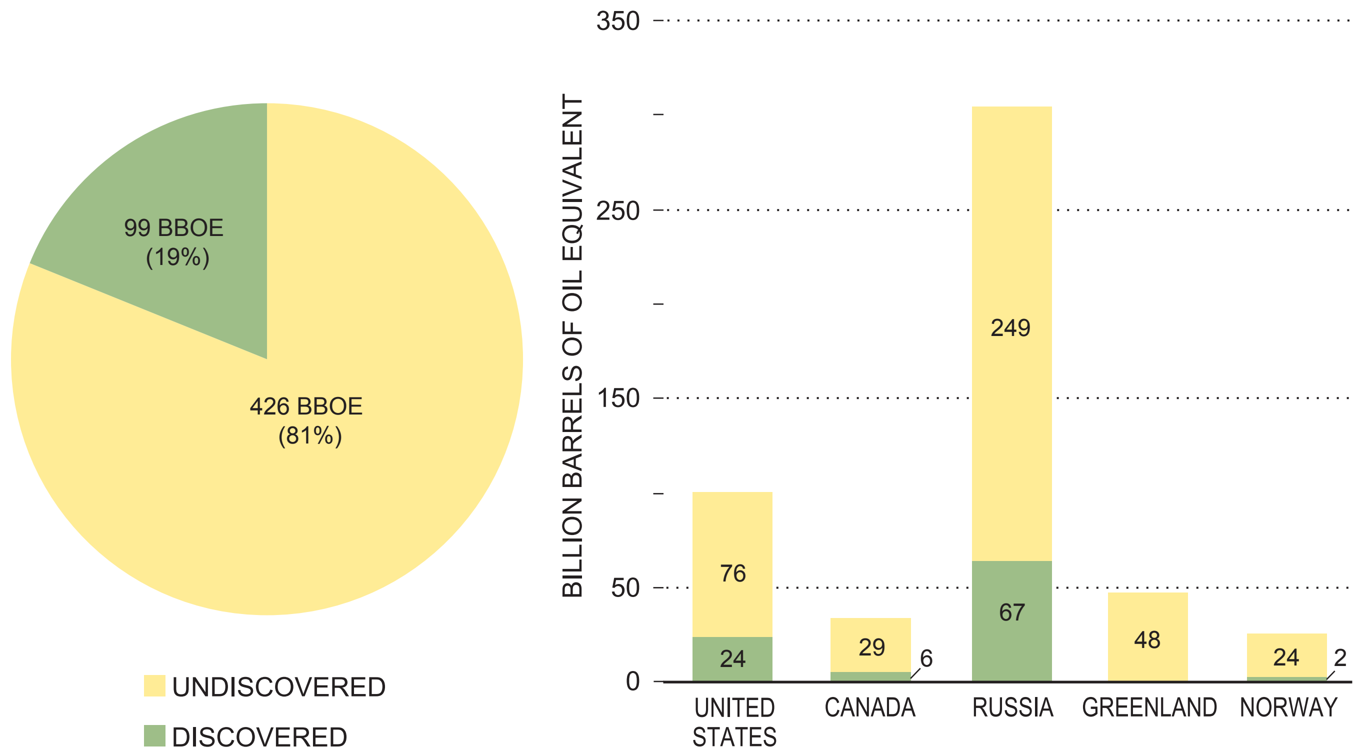


Figure 1-5. *Global Discovered and Undiscovered Arctic Conventional Resource Potential with Distribution by Country*

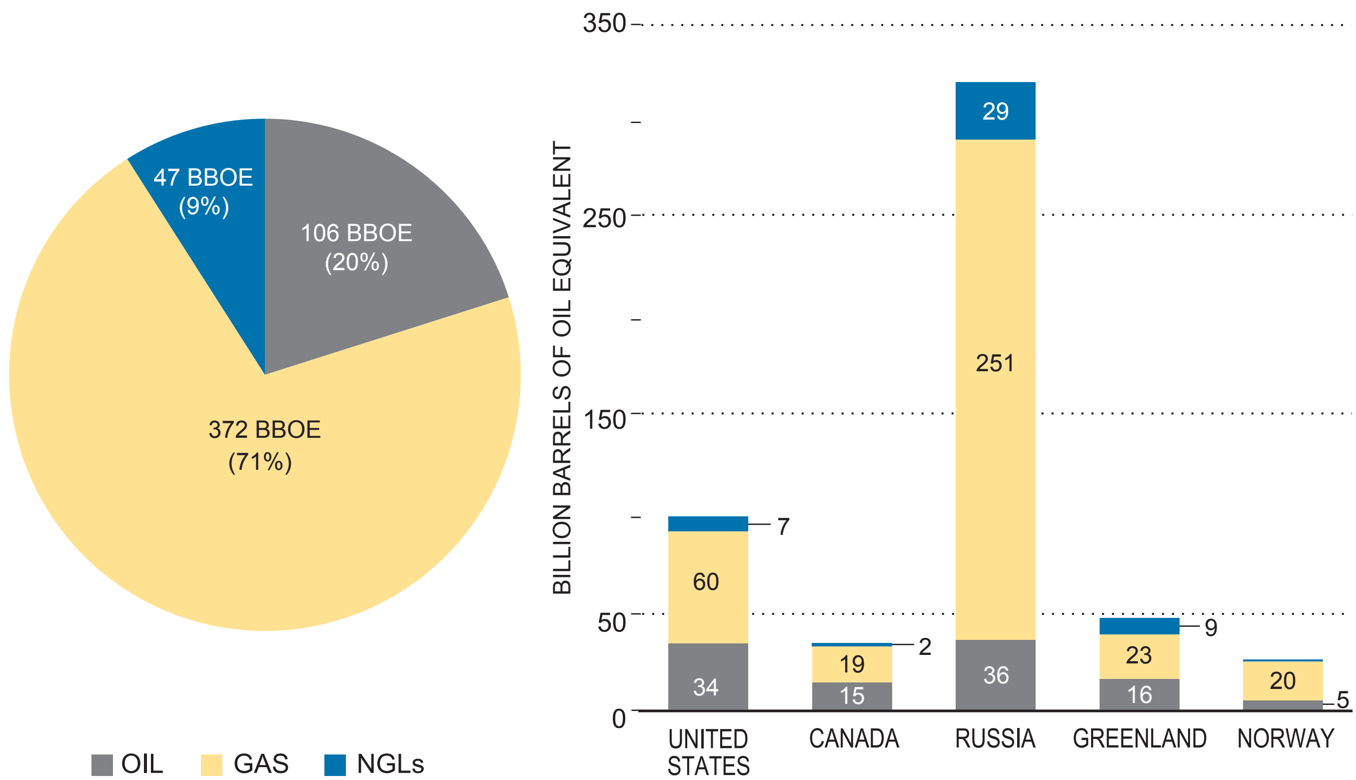


Figure 1-6. *Global Arctic Conventional Resource Potential by Petroleum Type (Oil, Natural Gas, and NGLs) with Distribution by Country*

supply. This, however, will require gas export infrastructure, which, in general, is currently lacking. Crude oil and NGLs account for the remaining 30% in the Arctic; a significant endowment considering it represents approximately 20% of the undiscovered conventional crude oil and NGLs remaining in the world.[25]

It is estimated that 389 BBOE (almost 75%) of the resource potential in the Arctic is located offshore, as shown in Figure 1-7. This is not surprising considering most Arctic production to date has been onshore. Given the additional complexity associated with offshore development, this part of the Arctic has remained largely underexplored and undeveloped. The Arctic offshore remains one of the most promising areas in the world for petroleum resource, a significant portion of which is assessed to be developable using existing ice-resistant technologies such as bottom-founded or gravity-based structures (GBSs).[a] The offshore estimate includes 348 BBOE of undiscovered conventional resource potential, as shown in Figure 1-8, 145 BBOE of which is assessed to be in water depths of less than 100 meters (m) and likely developable using bottom-founded structures.

a A gravity-based structure is a support structure held in place by gravity such as an offshore platform.

Russia is estimated to have 60% of the resource potential in the Arctic as shown in Figure 1-9. Most of Russia's endowment is assessed to be natural gas (almost 80% in oil equivalent barrels). Continental North America, including Greenland, accounts for 35% of the resource potential in the Arctic, with the United States (Alaska) having the largest endowment. Alaska is estimated to have approximately 100 BBOE, over 75% of which is undiscovered. Of Alaska's undiscovered portion, 32 billion barrels is assessed to be crude oil, making the United States and Russia the nations with the equal largest endowment of undiscovered conventional crude oil in the Arctic.

The resource potential for each Arctic nation is now discussed in more detail.

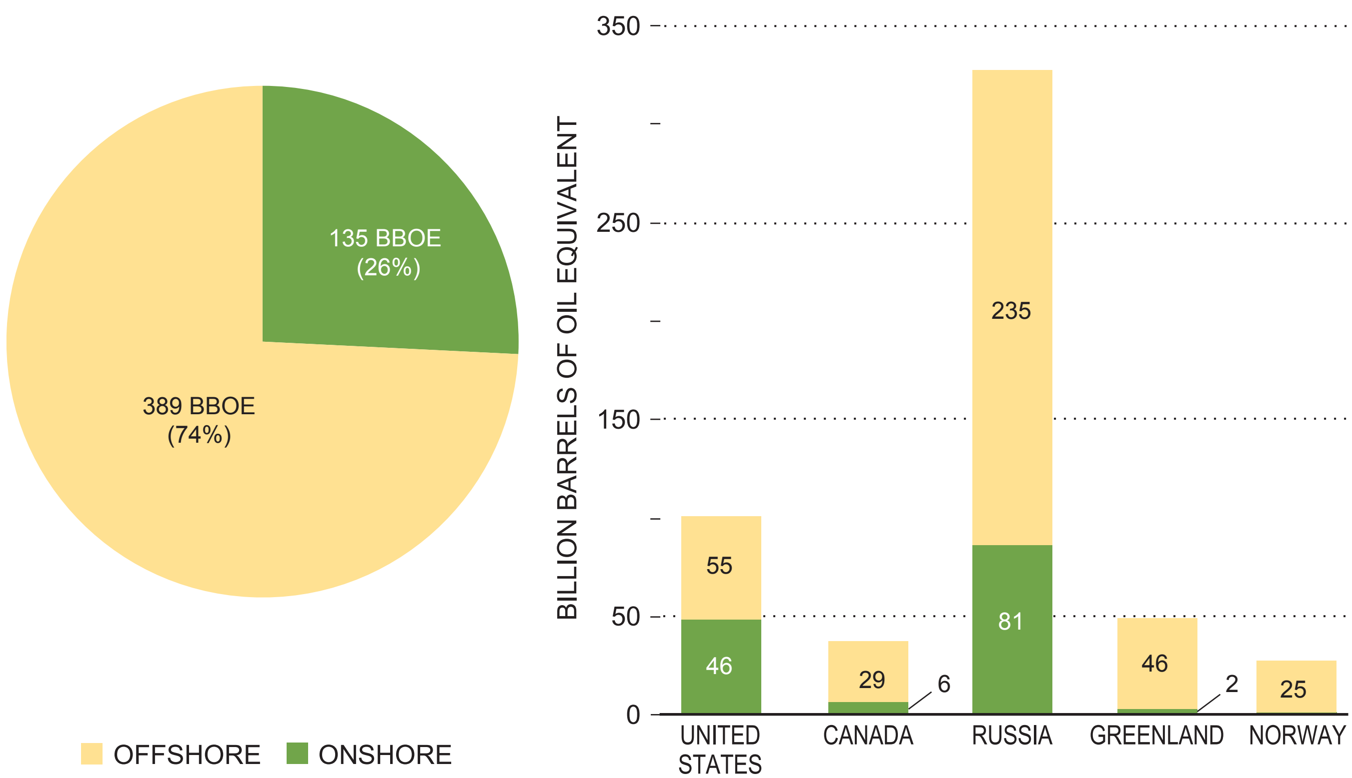
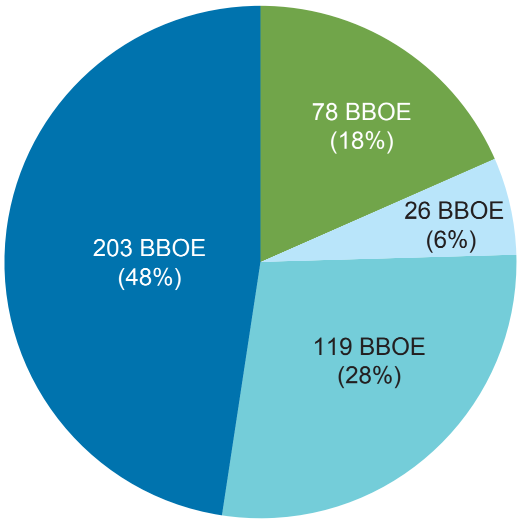


Figure 1-7. *Global Onshore and Offshore Arctic Conventional Resource Potential with Distribution by Country*



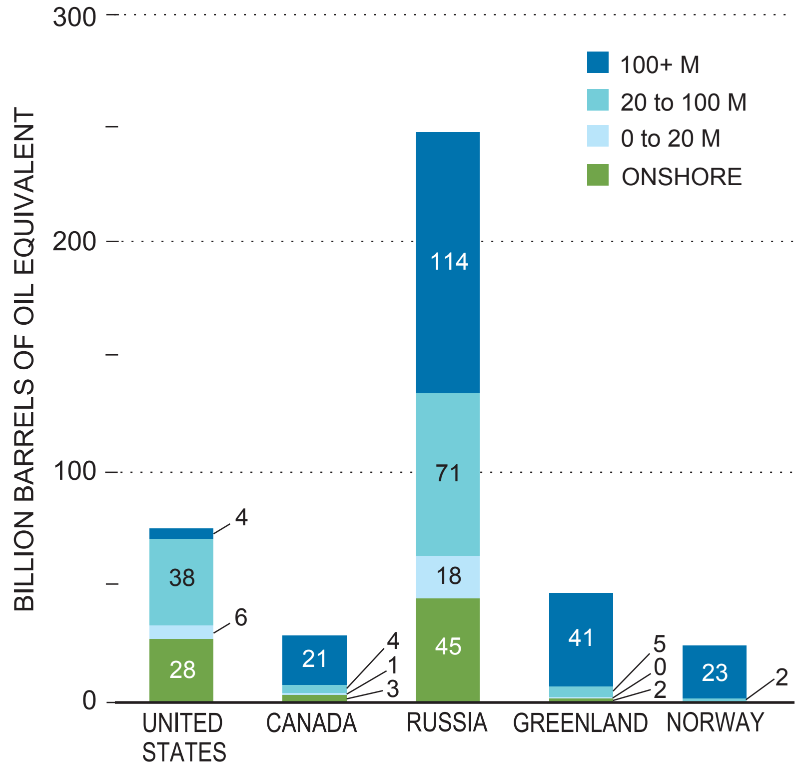


Figure 1-8. *Global Arctic Undiscovered Conventional Resource Potential by Water Depth with Distribution by Country*

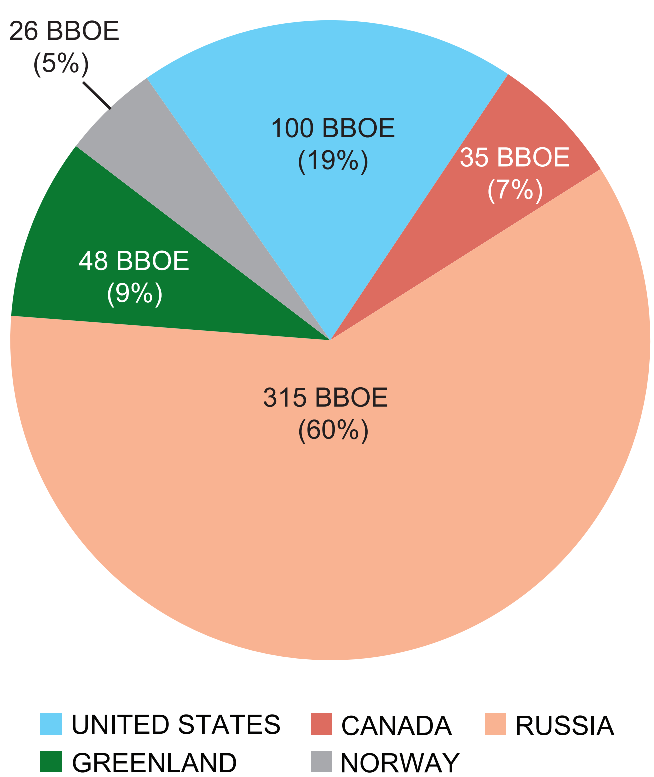
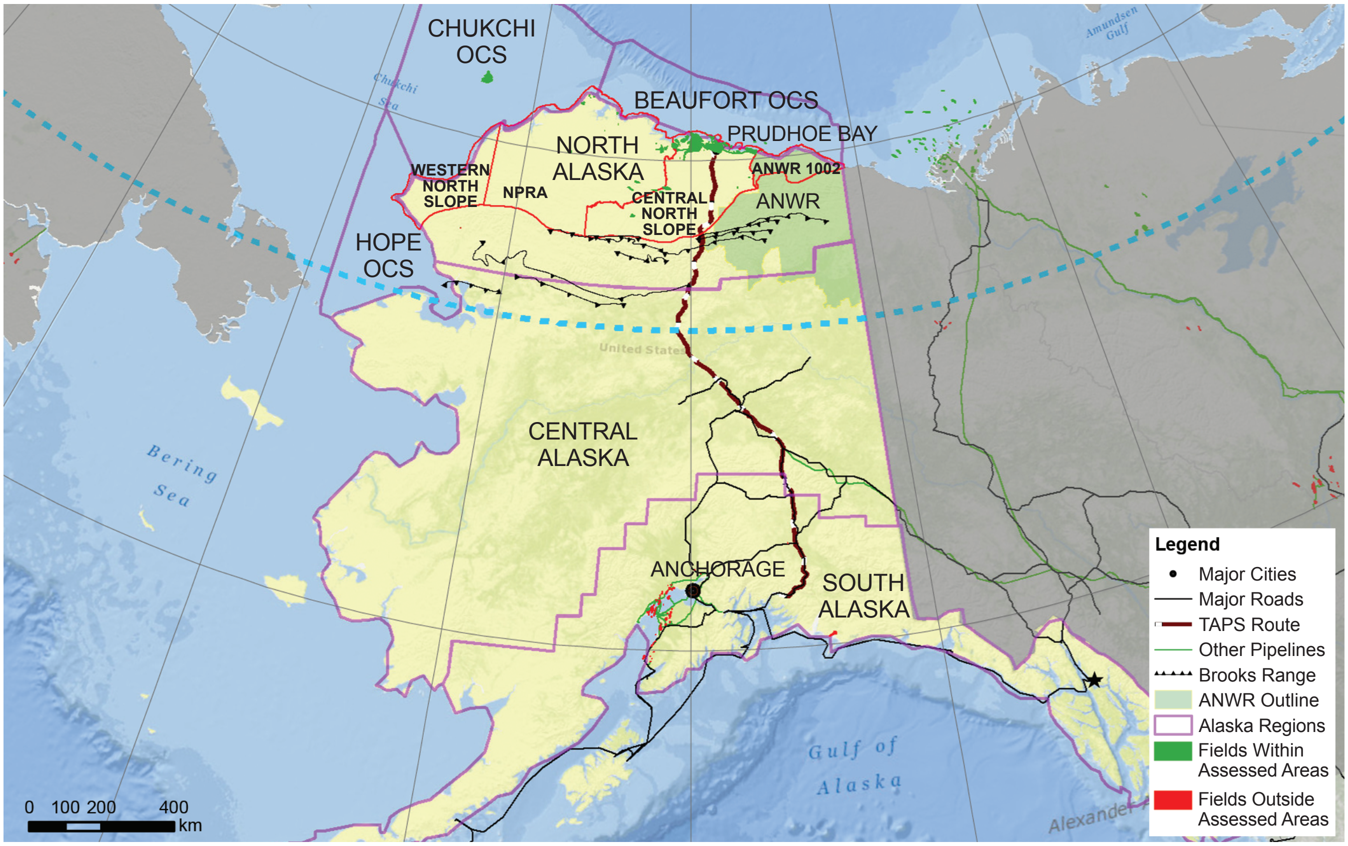


Figure 1-9. *Global Arctic Conventional Resource Potential Distributed by Country*

United States (Alaska)

The United States (Alaska) has produced over 16 billion barrels of crude oil in the Arctic, more than any other country to date,[26] and holds over 5 BBO reserves, which is second to Russia.[27] Most of the petroleum exploration and development in Alaska has been concentrated onshore, north of the Brooks Range, as shown in Figure 1-10. This area, commonly referred to as the North Slope, has been producing crude oil primarily from the central North Slope region between the National Petroleum Reserve in Alaska and the Alaska Wildlife Refuge (ANWR 1002). Oil production and export from the North Slope has been enabled by the Trans-Alaska Pipeline System, which was built in 1977 after discovery of the Prudhoe Bay field in 1968. Both oil and gas discoveries have been made in the North Slope, but gas is currently not exported due to a lack of gas export infrastructure. Instead, produced gas is used for fuel and reinjected into the reservoirs to enhance oil recovery.

Table 1-2 summarizes the total resource potential for Alaska as characterized in this section. Alaska is



Source for Fields Data: IHS, International E&P Database (online), September 3, 2014.

Figure 1-10. *Map of Alaska Showing Discovered Fields and the Areas Assessed for Resource Potential*

estimated to have 118 BBOE of resource potential (including undiscovered unconventional resource estimates for the North Slope and undiscovered conventional resource estimates for south and central Alaska). This includes 46 billion barrels of crude oil and NGLs and 430 TCF of natural gas.

The North Slope is estimated to have 61 BBOE of resource potential; over 50% of Alaska's total, as shown in Figure 1-11. Of this, only 18 BBOE is discovered.

Most of the North Slope's resource potential is assessed to be gas, as shown in Figure 1-12, with a significant portion already discovered but currently stranded due to a lack of gas export infrastructure. The region's long production history, combined with the lack of gas export, has contributed to the North Slope's current ratio of oil to gas potential. Only ANWR 1002 is estimated to have a larger liquid potential than gas in the North Slope; there has been no petroleum production from this area to date. ANWR 1002 is currently subject to a moratorium, which prohibits exploration and development.

The unconventional resource potential in Alaska comprises 1 billion barrels of oil and NGLs and 60 TCF of gas. This represents almost 20% of the North Slope's total resource potential, though this only accounts for recoverable volumes of shale oil and gas and coalbed methane. The portion of Alaska's petroleum potential due to unconventional resources will increase with consideration of other oil and gas sources, such as heavy oil and gas hydrates, which are the focus of ongoing studies to assess unconventional resources in Alaska and other parts of the Arctic. Gas hydrates in the North Slope alone are estimated to have a resource potential of 85 TCF of gas.[28]

The north Alaska offshore area, which comprises state waters and the Alaska OCS of the Chukchi Sea, Beaufort Sea, and Hope Basin, is estimated to have 51 BBOE of conventional resource potential. This includes 27 billion barrels of oil and NGLs and 143 TCF of gas. Of this, only 6 BBOE is discovered.

Alaska Study Areas				Resource Potential*		
				Oil + NGLs (BBO)	Natural Gas (TCF)	Total Resource (BBOE)
North Alaska	Onshore	Undiscovered	Western North Slope	0.2	9.1	1.7
			NPRA	1.6	50.5	10.1
			Central North Slope	4.3	35.8	10.2
			ANWR 1002	9	7.2	10.2
			North Slope Unconventionals	1.2	60.1	11.3
		North Slope Discovered		1.4	99.7	18.1
	Offshore	Undiscovered	North Slope State Waters	2	7.1	3.2
			Chukchi Sea OCS	15.4	76.8	28.2
			Beaufort Sea OCS	8.2	27.6	12.8
			Hope Basin OCS	0.2	3.8	0.8
		North Alaska Offshore Discovered		1.5	28.1	6.1
South and Central Alaska Onshore Undiscovered Conventional			Central Alaska (Yukon Flats)	0.4	5.5	1.3
			Southern Alaska (Cook Inlet)	0.7	19	3.9
Alaska				46.1	430.2	117.8

*Oil and NGLs shown in billion barrels of oil (BBO), Natural Gas in trillion cubic feet (TCF), and Total Resource in billion barrels of oil equivalent (BBOE). South and Central Alaska OCS volumes excluded.

Note: As per discussion in Methodology and Assumptions section, Alaska volumes are provided in more detail with some values obtained from U.S. sources other than the USGS 2008 Circum-Arctic Resource Appraisal (CARA). As such, total Alaska numbers in this section are slightly different than those quoted in the global discussion.

Table 1-2. *Summary of Alaska's Resource Potential*

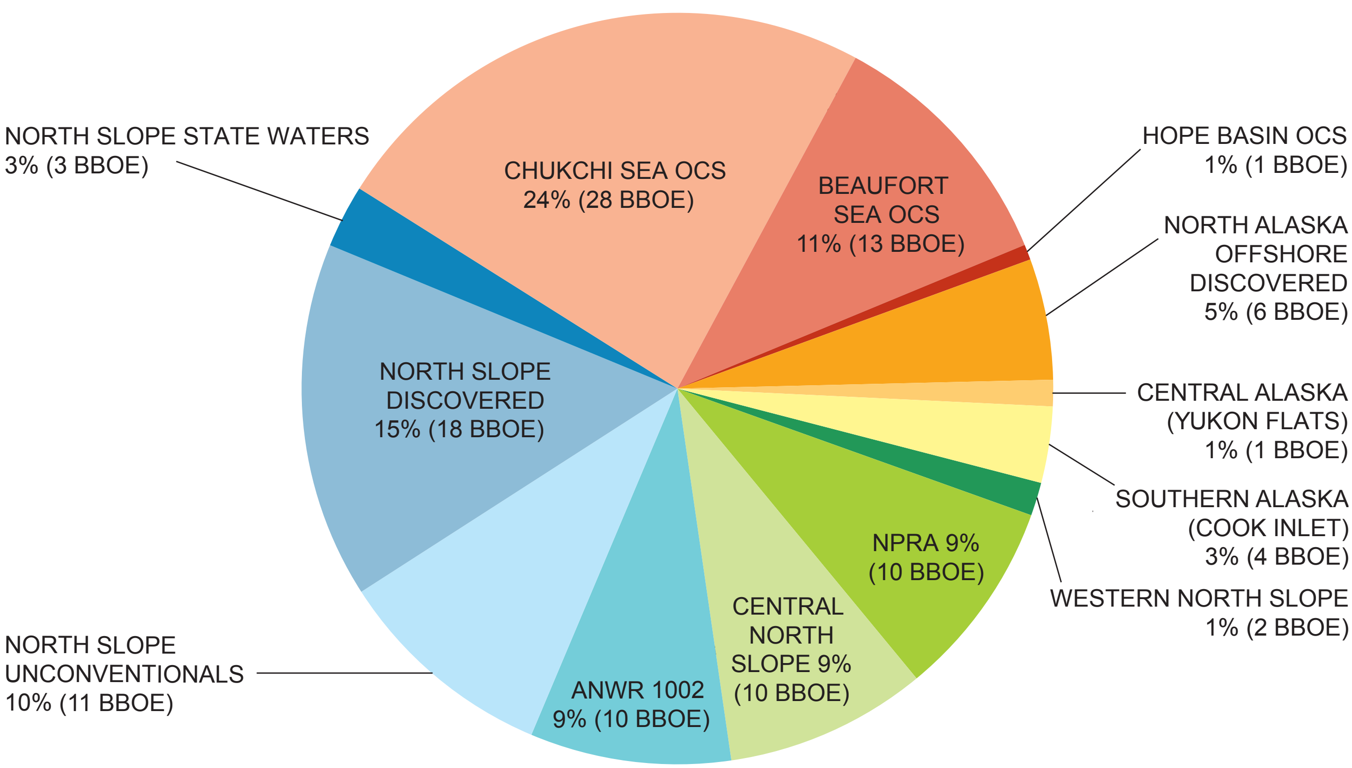


Figure 1-11. *Alaska Resource Potential Distributed by Region*

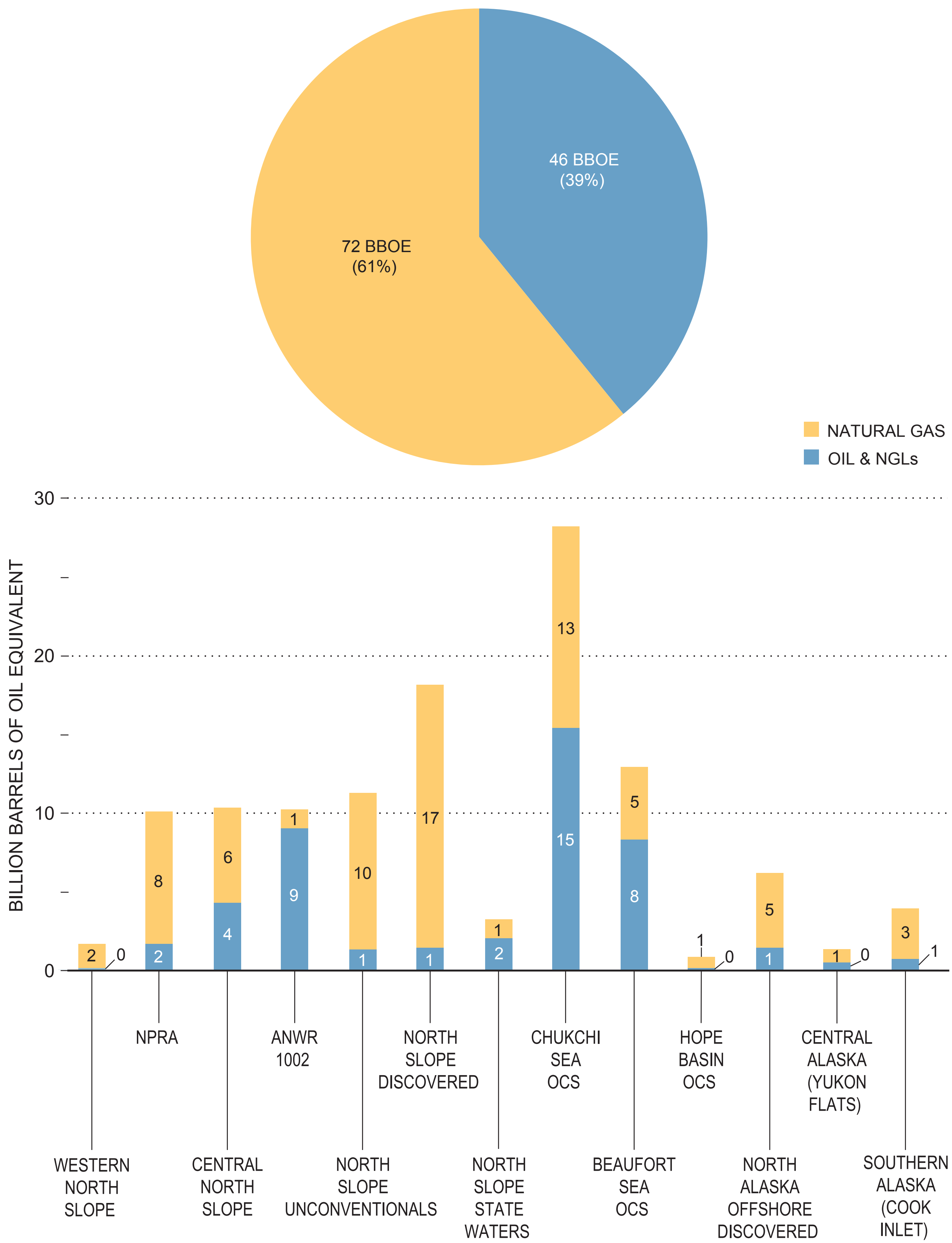


Figure 1-12. *Alaska Resource Potential by Oil & NGLs and Natural Gas with Distribution by Region*

The remaining 45 BBOE represents 55% of the undiscovered conventional resource potential in Alaska. Over 90% of Alaska's undiscovered offshore endowment is assessed to be in water depths less than 100 m, which, as previously mentioned, could be developed using bottom-founded structures. Past exploration efforts in both the Chukchi and Beaufort Seas have yielded discoveries, but development and production have been limited; the only OCS development to date is from the Northstar field, which straddles both federal and state waters in the Beaufort Sea.[29] The north Alaska offshore is still considered to be one of the more promising areas for petroleum in the Arctic, as reflected in lease sale participation in recent years. In 2008, several oil and gas companies placed bids totaling almost $3 billion for leases in the Chukchi OCS, an area estimated to have almost 65% of the undiscovered resource potential in the north Alaska offshore.

South and central regions of Alaska, though not Arctic regions, are mentioned because they are likely to experience similar design and technology challenges as those areas within the Arctic (e.g., permafrost).[30] South and central Alaska areas, including onshore and state waters, are estimated to have 5 BBOE, about 5% of Alaska's undiscovered conventional resource potential. Approximately 75% of this is in the Cook Inlet area of southern Alaska. Cook Inlet has been widely explored, with many mature fields producing since the 1950s. Despite this, the Cook Inlet area is still considered to have exploration potential for petroleum, especially because exploration activities waned upon discovery of the Prudhoe Bay field in 1968.[31]

Canada

The first commercial petroleum activities in the Arctic began in the Northwest Territories of Canada in the 1920s.[32] Canada's Arctic has produced over 270 million barrels of oil to date and is estimated to have over 790 MMBOE in reserves, most of which is gas.[33] Production from Canada's Arctic has come mainly from the Northwest onshore region. Several exploration wells have been drilled in the eastern offshore regions of the Canadian Arctic with some demonstrating the presence of hydrocarbons; however, no production or development is currently underway. Most of the petroleum activities on the eastern coast of Canada have been concentrated in the sub-Arctic regions of the Labrador-Newfoundland Shelf. Production from these areas is quickly increasing through developments of the Hibernia, Terra Nova, and White Rose fields, which have collectively produced more than 1 BBO.[34]

Canada is estimated to have 35 BBOE, which is approximately 25% of North America's Arctic resource potential (20% if Greenland is included in North America). This includes both discovered and undiscovered resources, with the undiscovered portion accounting for more than 80% of the total endowment. Canada is assessed to have more natural gas than crude oil, in oil equivalent barrels, most of which is located offshore and in the Northwest regions; only 6 BBOE is estimated to be in the eastern regions of the Canadian Arctic. Unlike Alaska, however, most of Canada's undiscovered offshore resource potential is located in water depths exceeding 100 m, which will likely require floating or subsea technologies for development.

Russia

Russia has produced the most gas from the Arctic, more than any other country to date, and is the largest gas producer. Over 8 billion barrels of crude oil and NGLs have been produced, representing almost 35% of the total Arctic liquid petroleum production.[35] Over 550 TCF of gas have also been produced, which is almost all of the total Arctic gas production.[36] In addition, Russia is assessed to have over 31 billion barrels of crude oil and NGLs and 906 TCF of gas in reserves.[37] Major discoveries in the 1960s led to Russia's first commercial Arctic production from the Nenets and Republic of Komi regions in the 1970s and 1980s.[38] Similar to Alaska, most of the current production in the Russian Arctic has been onshore, leaving the offshore largely underexplored, though there have been sizable discoveries made. One of the world's largest gas fields, Shtokmanovskoye, discovered in the Russian Barents Sea, is estimated to have approximately 95 TCF of natural gas and 300 million barrels of condensate recoverable.[39]

In addition to having the largest production of gas in the Arctic, Russia is also assessed to have the largest resource potential in the region. Russia is estimated to have 315 BBOE (60% of the Arctic resource potential), almost 80% undiscovered. Most of Russia's endowment is assessed to be gas with only 20% being oil and NGLs in oil equivalent barrels. While Russia's liquid resource potential may represent the minority share of its hydrocarbon portfolio, it is still the largest of any other nation in the Arctic at 65 BBOE; these large volumes suggest that Russia will likely continue to play a significant role in Arctic oil and gas production over the next 50 years.

More than 203 BBOE of Russia's resource potential is located offshore, a large portion being gas concentrated in the Barents, Laptev, and Kara Seas. Both shallow and deep water regions in Russia's Arctic offshore are assessed to have significant undiscovered conventional resource potential: 89 BBOE in less than 100 m and 114 BBOE in greater than 100 m. Russia's Arctic offshore represents one of the world's most promising and least explored offshore areas.

Greenland

Petroleum activities in Greenland date back to the 1970s when the first exploration licenses were issued.[40] Exploration wells drilled in the 1970s and 1990s demonstrated the presence of hydrocarbons, but no discoveries were significant enough to facilitate commercial exploitation. Greenland remains the only of the five Arctic nations without petroleum production.

Despite having no commercial petroleum production, Greenland is considered to have the third largest resource potential in the Arctic at 48 BBOE, behind Russia and the United States. This represents almost 10% of the total Arctic endowment. More than 50% of Greenland's undiscovered conventional resource potential is assessed to be liquid (in oil equivalent barrels), consistent with other countries in continental North America.

Almost all of Greenland's resource potential is assessed to be offshore, approximately 90% in water depths of over 100 m. Historically, exploration efforts have been almost exclusively concentrated in West Greenland but, following Cairn Energy's extensive but disappointing exploration campaign in 2010 and 2011, Greenland's northeastern region has come into focus. More than 30 BBOE is estimated to be in this region, where leases have been awarded as recently as December 2013 to companies such as Statoil, ENI, and Chevron.[41] Offshore Northeast Greenland is considered one of the most challenging environments in the Arctic, with both sea-ice and icebergs frequently occurring.[42]

Norway

Norway's Arctic petroleum production has been primarily from the Norwegian Continental Shelf in the Norwegian and Barents Seas. Over 1 TCF of gas have been produced from the Norwegian Arctic to date. The region is also estimated to have over 376 million barrels of crude oil and NGLs and 8 TCF of gas in reserves.[43] Norway's petroleum industry began systematic operations in the 1980s, with exploration beginning in the Norwegian Sea and discovery of the Snøhvit gas field in the Barents Sea.[44] Continued exploration efforts in the Norwegian Arctic have been quite successful and have led to pioneering developments such as the only LNG facility north of the Arctic Circle.[45] Exploration efforts are also expected to increase in coming years, with additional acreage in the Barents Sea now available following recent resolution of a border dispute with Russia.

More than 25 BBOE of resource potential is estimated to be in the Norwegian Arctic, including 2 BBOE already discovered. Norway's resource potential represents 5% of the total Arctic endowment. Approximately 80% of Norway's Arctic resource potential is assessed to be gas, similar to Russia. Almost all of Norway's Arctic resource potential is concentrated in the Norwegian and Barents Seas, most of which is in water depths 100 m or greater and in generally open water. Future exploration efforts are expected to be focused in the Barents Sea, which is estimated to have approximately 75% of Norway's Arctic undiscovered conventional resource potential.[46] The Norwegian government proposed to offer 61 blocks in its 23rd licensing round with 54 from the Barents Sea (34 from the previously disputed areas) and 7 from the Norwegian Sea. At the time of writing, a final decision on the blocks to be offered had not been made.[47]

Conclusions

There is significant Arctic resource potential globally and within the United States. Extensive exploration over many years will be required to reduce the estimate uncertainty. The resource size and distribution, as well as the physical ice and bathymetric environment will continue to underpin the timing and methods for prudently developing this vast resource.

Following is a summary of the key conclusions relating to global Arctic resource potential.

- The global Arctic has 525 BBOE of resource potential with 70% (372 BBOE) expected to be gas. 80% (426 BBOE) is undiscovered conventional which represents 25% of the global undiscovered conventional resource potential.
- Globally, 75% (389 BBOE) of the Arctic resource potential is expected to be offshore.
- The majority of the global potential is in Russia, which is assessed to have 251 BBOE gas, 36 BBO, and 29 billion barrels of NGLs.
- The United States is estimated to have approximately 20% (100 BBOE) of the global Arctic resource potential, with approximately 40% (40 BBOE) estimated to be liquids.
- Both the United States and Russia are estimated to have similar volumes of discovered plus undiscovered conventional oil at around 35 BBO each.

Considering Alaska's resource potential:

- 90% of Alaska's offshore undiscovered conventional volumes are in water depths less than 100 m and can likely be developed using gravity-based or bottom-founded fixed structures.
- Approximately 55% (24 BBOE) of Alaska's undiscovered conventional liquid resource potential is in the Chukchi Sea and Beaufort Sea OCS combined.
- Though data are limited, unconventional resources, both globally and in Alaska, could be significant; however, some of these resources, such as gas hydrates, are not expected to be developable in the United States for the next several decades.

HISTORY OF ARCTIC OPERATING EXPERIENCE AND THE DEVELOPMENT OF ENABLING TECHNOLOGIES

Scope

This section of the chapter provides a historical context of exploration and development in the onshore and offshore Arctic and sub-Arctic. A summary of technology advancements and key milestones is provided upfront. The remainder of the section is primarily organized geographically, generally with the onshore discussion first, followed by the offshore discussion. For each region, historical activities and the corresponding technology developments are summarized. The regional descriptions begin with Arctic Canada and Alaska, where the bulk of the foundational technologies evolved, followed by summaries for Russia, Norway, and Greenland. The section concludes with a brief description of some of the key recent or planned Arctic exploration and development activities.

Introduction

The presence of petroleum in the Arctic has been known for centuries. The Dene people of the region around Norman Wells in Canada have long called the area "Le Gohlini," which means "where the oil is." In 1789, explorer Sir Alexander Mackenzie wrote about seeing oil seeping into the Dehcho River as he paddled through the region.

The first commercial discovery of oil in an Arctic-like area was by Imperial Oil at Norman Wells in 1920. It has been followed by the drilling of thousands of onshore and offshore wells across the Arctic, with the majority of the early offshore exploration wells being drilled in the United States and Canada, as shown in Figure 1-13. Billions of barrels of oil and trillions of cubic feet of gas have been produced. Along the way, industry has developed experience in exploring, developing, and producing in this remote region.

Innovation has been the foundation for progress and overcoming the challenges of Arctic development. From the installation of the first platform in Cook Inlet in the 1960s, to the construction of the Trans-Alaska Pipeline System, to the more recent development of the Hibernia platform in "Iceberg Alley," technology has progressed to allow development in more complex environments. Industry has benefited from the local knowledge and experience from preceding developments, both Arctic and non-Arctic, and has advanced engineering design, technology, and operating practices. What began with a single onshore Arctic well has led to successively more complex onshore and offshore developments that have allowed over 23 BBO and 550 TCF of gas to be produced over several decades. Industry has demonstrated a strong track record of safe and responsible development and a commitment to continually improve, with few major incidents that have mainly occurred outside of the Arctic, as shown in the text box titled "Safety Improvements in the Oil and Gas Industry."

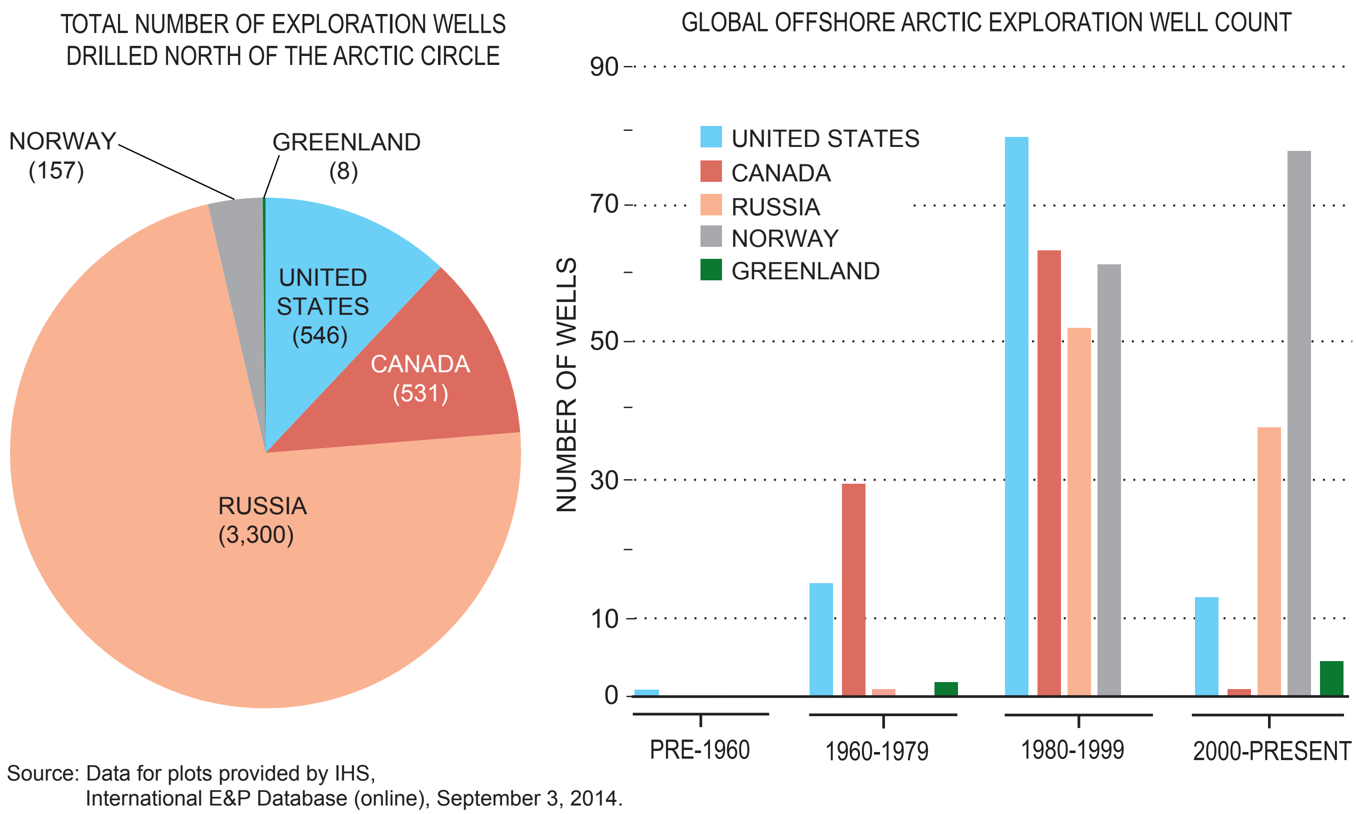


Figure 1-13. *Global Exploration Wells Drilled North of the Arctic Circle (Split by Country and Time Period)*

Summary of Arctic Milestones and Technology Advances

Arctic exploration and development has advanced over the last 50 years. Technology and operating experience have enabled more complex challenges to be overcome to prudently develop the world's energy resources. Beginning with the discovery of oil in Alaska's Cook Inlet, industry has engineered designs to overcome some of the significant challenges associated with ice loads on platforms. That experience served as the foundation for subsequent developments that overcame other elements of the physical environment, such as water depth and winter drilling in ice. Figure 1-14 depicts the technology progression in offshore Arctic exploration and development over the last 50 years, and Figure 1-15 provides a chronology of major Arctic milestones of the last century.

Canada

From the first major onshore Arctic-like development in North America at Norman Wells to extensive onshore and offshore exploration in the Arctic Islands and Canadian Beaufort Sea, activity in Canada has been foundational for development of offshore technology for oil and gas exploration and development. Together with U.S. advances, the learnings from Canada activities from the 1960s to 1980s remain key to how some of today's largest and most complex offshore Arctic projects are explored, developed, and produced. Figure 1-16 highlights Canada's key Arctic and sub-Arctic oil and gas areas.

Norman Wells—First Major Onshore Arctic Development in North America

The Geological Survey of Canada confirmed the presence of oil in the Norman Wells region in 1888. By 1911, traces of an oil-bearing formation were found. Nine years later in 1920, Imperial Oil drilled the discovery well that would ultimately become the first oil production in Arctic conditions in North America.

Given its remote location and extremely cold winter temperatures, early production from the field was

Safety Improvements in the Oil and Gas Industry

Safety is the highest priority for all stakeholders and a core value for industry. However, over the last several decades, a small number of major incidents have had significant consequences, including in some cases the tragic loss of life. The industry and regulators have responded with reforms that substantially improved safety and environmental performance of the industry. Some examples of major incidents during exploration, development, and production include:

1988 – Production platform Piper Alpha in the North Sea off of the United Kingdom was destroyed by an explosion and resulting fire, with a loss of 167 crew members. Key reforms include:

- Stringent design requirements including wind tunnel testing and explosion simulations and improved and multiple escape route to helicopters and lifeboats during evacuation
- Clear identification of a person in charge who has the ultimate decision-making authority with regards to safety and the environment
- New regulations mandate operators must demonstrate that an effective safety management system is in place.

2010 – While drilling in the Gulf of Mexico, the Deepwater Horizon rig experienced a blowout and explosion that killed 11 workers. The well was capped 87 days later. Key reforms include:

- Enhanced drilling safety regulations including new standards for well design, casing, and cementing as well as independent certification
- Subsea containment devices as a requirement of spill response plans
- Increased emergency response preparedness requirements including worst-case discharge planning.

In addition, examples of maritime incidents that occurred during oil and gas exploration, development, or production include:

1989 – The *Exxon Valdez* ran aground in Alaska's Prince William Sound. Despite efforts to stabilize the vessel, more than 250,000 barrels of oil were spilled. Key reforms include:

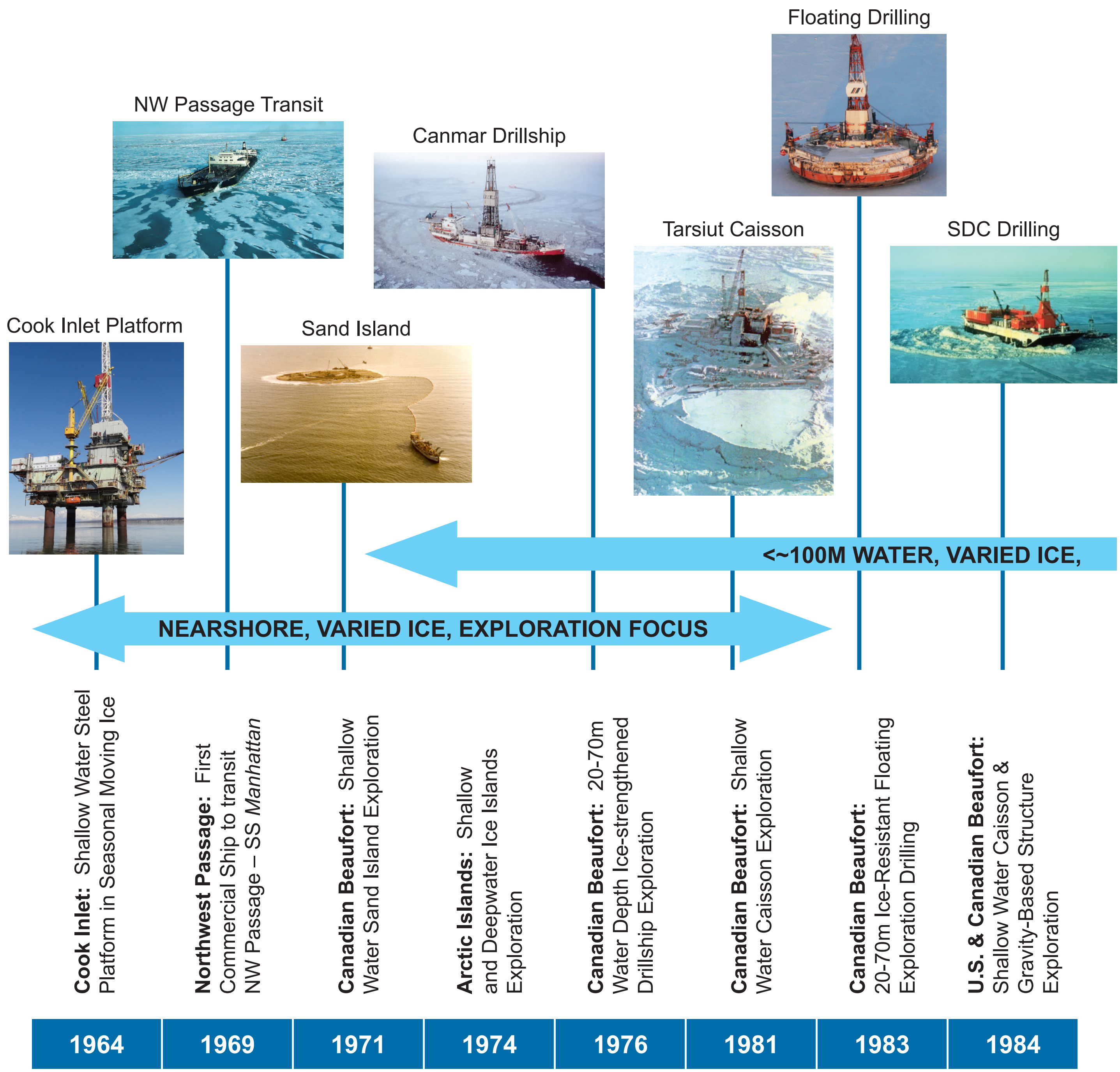
- Passage of landmark legislation to improve American oil spill prevention and response
- New requirements for contingency planning, both by government and industry
- Establishment of new tanker design and tug escort criteria
- Development of an integrated operations integrity management system by the operator.

2012 – During towing of the drilling rig *Kulluk* from Dutch Harbor, Alaska, to Seattle, Washington, the towline parted and the *Kulluk* ultimately ran aground in rough weather on Sitkalidak Island near Kodiak, Alaska, on December 31, 2012. There were no serious injuries or environmental damage. Key reforms include:

- U.S. Coast Guard and Towing Safety Advisory Committee task group set up to assess strengthening global guidelines for towing offshore drilling rigs and harsh weather risk assessment, due spring 2015
- U.S. Coast Guard recommendations for all operators to reevaluate towing procedures and consider new criteria for tow planning in the Arctic.

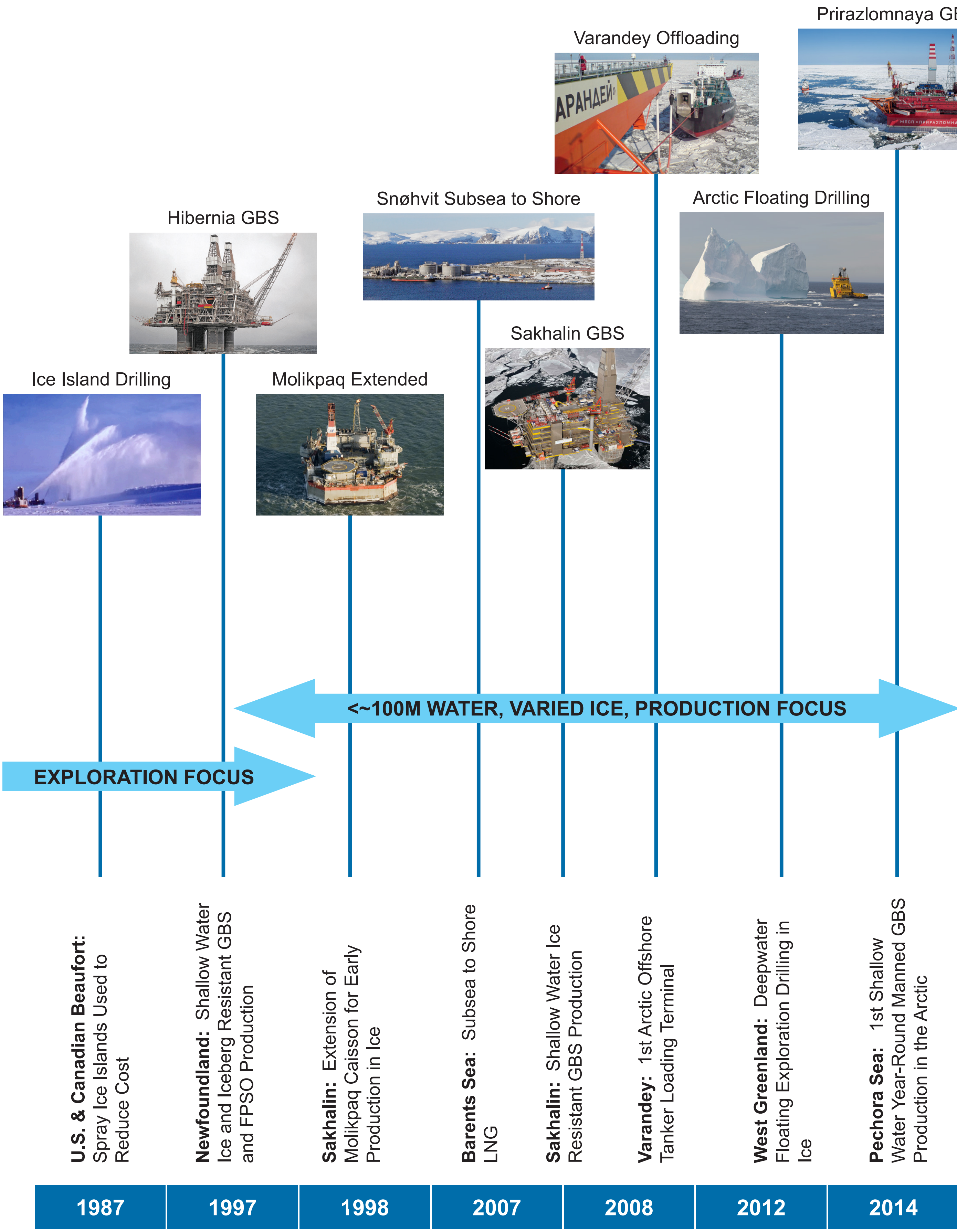
seasonal and intermittent and only produced crude oil to meet local energy needs. That changed at the onset of the Second World War when investment and activity flowed into the field to provide a year-round oil supply for Allied forces. The Canol project included 67 new wells and a pipeline from Norman Wells to Whitehorse, Yukon, where production was delivered to a new purpose-built refinery until it closed at the end of the war.

Most of the Norman Wells field is under the Mackenzie River, which is about 2 miles wide at this location. As a result, when Imperial began its expansion in 1982, the development included 6 artificial islands designed to withstand seasonal water level changes and loads from ice floes. A total of 253 new wells were drilled and a 520-mile pipeline installed from Norman Wells to Zama, Alberta.



Photos, left to right: Cook Inlet platform - Hilcorp; NW Passage Transit - ExxonMobil; Sand Island - John Waring; Canmar Drillship - R. Pilkington; Tarsiut Caisson - G. Timco; Floating Drilling - Shell; SDC Drilling - G. Timco & I. Morin.

Figure 1-14. *Technology Progression Spanning 50 Years to Explore and Develop in Offshore Arctic Conditions*



Photos, left to right: Ice Island Drilling - BP – Amoco; Hibernia GBS - ExxonMobil; Molikpaq Extended - Sakhalin Energy; Snøhvit Subsea to Shore - Statoil (Harald Pettersen); Sakhalin GBS - Sakhalin Energy; Varandey Offloading - MacGregor Pusnes AS; Arctic Floating Drilling - Viking; Prirazlomnaya GBS - Gazprom.

Figure 1-14. *Technology Progression Spanning 50 Years to Explore and Develop in Offshore Arctic Conditions (continued)*

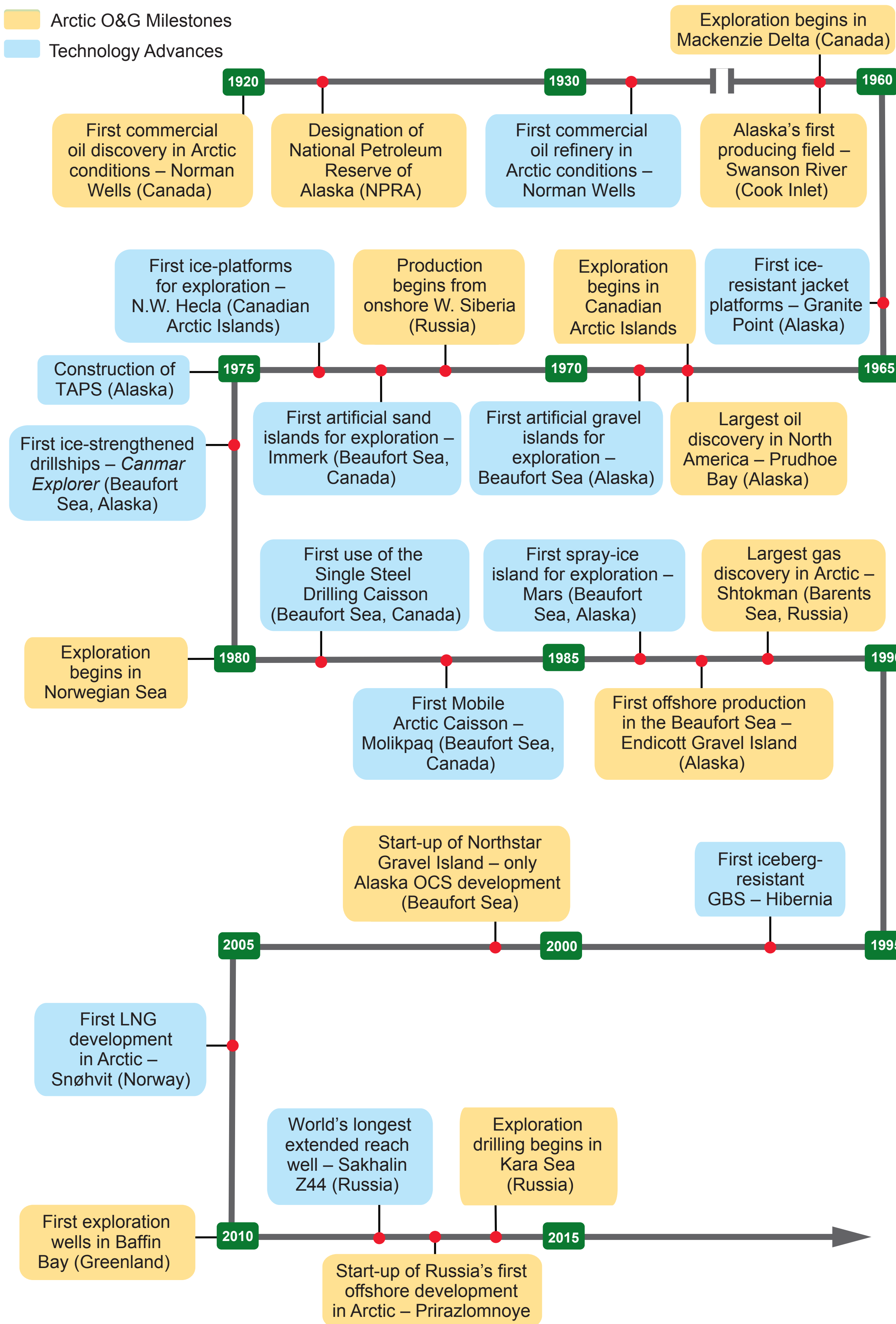


Figure 1-15. *Chronology of Select Global Arctic Oil and Gas Milestones*

Figure 1-16. *Map of Canada Highlighting Key Arctic and Sub-Arctic Exploration and Development Areas*

Since its discovery, Norman Wells has faced significant operating and logistical challenges. The climate can be extreme with winter temperatures dropping as low as –60 degrees Fahrenheit. The field has no all-weather roads to access the nearest major community of Edmonton, Alberta, which is more than 1,000 miles away. Supplies are trucked over 300 miles of winter ice roads or barged nearly 350 miles up the Mackenzie River during the summer months. During winter months, access to the fields' islands with heavy equipment is limited to across-ice transportation.

Arctic Islands—First Exploration Drilling from Ice Islands

After the first well was drilled in the Arctic Archipelago in the winter of 1961-62, exploration in the Sverdrup Basin of the Canadian Arctic Islands region was primarily performed between 1968 and 1986 by Panarctic Oils Limited (a consortium of 37 companies and the Canadian government established to explore for oil and gas in the Arctic Islands). Panarctic drilled 150 wells over an area measuring more than 1 million sq. km.[48] As shown in Figure 1-17, although the majority of Panarctic's wells were onshore, 38 offshore wells were drilled from floating ice platforms in water depths up to 550 m. All other operators accounted for an additional 37 onshore wells drilled in the area.[49]

Approximately 17.5 TCF of natural gas and 12 million barrels of oil were discovered at Bent Horn on Cameron Island.[50] In 1985, the first shipment of 100,000 barrels of this oil was delivered by an icebreaking tanker to a refinery in Montreal.[51] When these shipments were discontinued in 1997, a total of 2.8 million barrels of oil had been produced.[52]

Onshore drilling was logistically challenging given the extreme remoteness and harsh weather conditions. The majority of equipment, including drilling rigs, supplies, and fuel, was annually sealifted into Rea Point during a short 2-week window at the end of summer. These supplies were then moved across the region by aircraft and trucks or by tracked or rubber-tired all-terrain vehicles.

Figure 1-17. *Arctic Islands Exploration Well Map*

Offshore drilling required a major technological step due to the very limited open water season and minimal ice-free months. Instead of drilling in the open water months, offshore drilling was conducted in the winter on ice platforms up to 5 m thick, constructed by either flooding the existing sea ice with seawater or spraying with high pressure pumps. A modular rig design was developed to allow for air transportation to improve efficiency and cost effectiveness and reduce rig-up time. Well duration, including rig-up, drilling, logging, and testing, was limited to about 90 days to meet same season relief well requirements.

Canadian Beaufort Sea—First Use of Sand Islands and Arctic Drillships

Exploration activity in the Mackenzie Delta/Beaufort Sea region began onshore in 1957 with early reconnaissance-level ground and air studies. In 1962, the first two wells were drilled on the Beaufort Sea coast followed by onshore drilling at the Reindeer site on Richards Island. In 1970, Imperial reported the first oil discovery at Atkinson Point followed by major gas discoveries by Imperial at Taglu (1971), Gulf at Parsons Lake (1972), and Shell at Niglintgak (1973). This resulted in increased exploration and investment and spurred the 1974 proposal for a Mackenzie Valley Pipeline.

Offshore drilling in the Canadian Beaufort Sea began in 1973 with Imperial drilling two wells from artificial islands. In 1976, drilling from ice-strengthened drillships accessed deeper waters and activity continued until 1990. The most significant discovery was that of the Amauligak oil and gas field by Gulf Canada Resources.

Unfortunately, beyond these discoveries, the Mackenzie Delta/Beaufort Sea region was characterized by a large number of smaller, widely scattered resources. As a result, interest in continued exploration activity in the region waned. In 1999-2000, increasing North American gas prices and the revival of plans for the Mackenzie gas pipeline drove increased seismic exploration and drilling activity in the Mackenzie Delta. However, it was short lived with Devon's Paktoa C-60 well, drilled in 2005-06, the only Canadian Beaufort Sea offshore well drilled in the last 24 years.[53]

Despite the difficult environment, National Energy Board records show that 92 offshore wells have been drilled in the Canadian Beaufort Sea region without significant incident,[54] with numerous innovative drilling platforms and techniques developed and operated successfully. These techniques later became foundational for activities across the global Arctic.

Sandbag retained islands were first used in 1975 in shallow waters with limited open water season and landfast ice. A ring of sandbags is placed on the seafloor to contain the fill. The fine grain material allows for a relatively steep slope, offering protection against waves. Clam-shelled local seabed materials and soils barged to the site from remote submarine borrow pits were used for fill. A schematic example of one of 13 such islands constructed is shown in Figure 1-18. Although they served their purpose, the construction method and materials meant that they had a limited depth of around 7 m.

To extend the use of islands in deeper water, sacrificial beach islands like Issungnak were created as shown in Figure 1-19. The flat beach-like slopes allowed wave energy to be attenuated and provided an erosion buffer. However, given the amount of material required, these islands were primarily constructed from fill dredged locally. As deeper islands were considered, this method became cost prohibitive.

To reduce island fill volumes in depths beyond 15 m, caissons[b] were used in the 1980s. The main caissons included:

- Tarsiut caissons
- Single Steel Drilling Caisson
- Caisson retained island
- Molikpaq mobile Arctic caisson.

Although the details of each system varied, deployment of all systems commenced with the building of a steep-sided subsea sand berm on the seafloor on which

b A caisson is a steel or concrete structure that serves as the foundation for a rigid offshore platform or rig.

Source: Chevron.

Figure 1-18. *Typical Sandbag Retained Island Schematic*

Photo: G. Timco.

Figure 1-19. *Constructing Issugnak Island (1980)*

the caisson was set. Then the caisson was filled with water. While the basic design issues were similar to any other major civil work, the unique environmental loads necessitated extensive instrumentation to monitor structure performance to ensure well safety was maintained. Installation was also challenged by the short working season and presence of ice. Figure 1-20 shows the initial placement of the Tarsiut caissons in 22 m water depth and Figure 1-21 shows the Molikpaq caisson in 30 m water depth. The Molikpaq was later modified to become a production platform off the coast of Russia's Sakhalin Island.

As water depth increased, artificial islands became impractical, but the desire to drill in deeper water continued, and specially converted ice-strengthened drilling ships began to be used during the summer months. Three such drillships, *Canmar Explorers I, II,* and *III* (see Figure 1-22), were initially used starting in 1976 and, given the ice conditions, were supported by four icebreaking tug/supply vessels and a bulk supply carrier. The drillships were equipped with eight mooring lines incorporating remote anchor release

Photo: G. Timco.

Figure 1-20. *The Tarsiut Caisson*

Photo: Gulf Canada Resources.

Figure 1-21. *The Molikpaq Caisson*

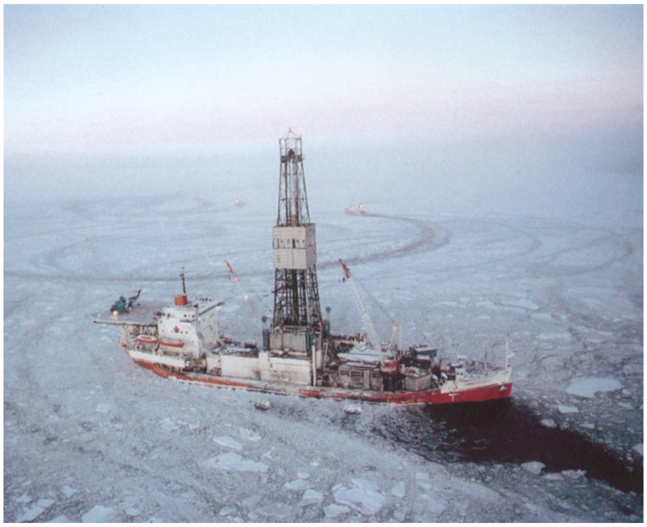


Photo: R. Pilkington.

Figure 1-22. Canmar Explorer *Drillship*

Photo: Shell.

Figure 1-23. Kulluk

units, which, in conjunction with other equipment, allowed quick disconnection from the anchors. This enabled the ship to withdraw from the drilling location quickly—to keep people and equipment safe and to protect the environment—in the event of ice encroachments that could not be managed within the levels of mooring capacity. Additionally, ice management operations including ice alert procedures were used, the "big bit" was developed to drill mudline cellars,[c] and drilling procedures were modified to deal with subsea permafrost. In 1979, the fleet was boosted by the drillship *Canmar Explorer IV*, which used underwater fairleads[d] to protect the anchors from winter ice and was supported by an icebreaker.

To improve on the limitations of ice-strengthened conventional drillships, an axis-symmetrical drilling vessel called the *Kulluk*, shown in Figure 1-23, was constructed in 1983 and began operations shortly thereafter. With its double-walled, inward-sloping hull, this vessel could operate safely in open water conditions in the summer and also withstand ice loads encountered during late thaw and early freeze-up, thus extending the drilling season. When on station, it was held in position by 12 radially deployed mooring lines. The barge was supported by a fleet of purpose-built icebreakers and supply vessels. Ice management that allowed activity into December, involved advanced ice-monitoring activities, icebreaking by the unit itself as well as by the icebreaking support vessels.

c Mudline cellars are holes used to protect wellheads from ice keel and other impacts.

d A fairlead is a device to guide a line, rope, or cable around an object, out of the way, or to stop it from moving laterally.

Newfoundland—First Iceberg-Resistant GBS and FPSO in Sea Ice and Iceberg Regions

Exploration and development of eastern Canada's offshore oil and gas resources in the Newfoundland and Labrador areas has progressed over several decades. Long open water seasons combined with use of traditional deepwater development systems that have been adapted for ice prone conditions have allowed several fields to be developed. From the Hibernia GBS to the White Rose and Terra Nova floating production vessels, production system technology suitable for an area where icebergs are present has continued to evolve.

The Hibernia field was discovered offshore Newfoundland in 1979, and, with 1.3 billion recoverable barrels, it is one of the largest fields ever discovered in Canada. Following ten appraisal wells, Hibernia was developed in the 1990s. In 80 m of open water, far beyond the reach of artificial islands, and with the threat of an iceberg as a key design challenge, a gravity-based structure with offshore tanker loading and extended-reach platform wells was designed. The first of its kind, the GBS, as shown in Figure 1-24, was designed and built using high-strength, steel-reinforced concrete with pre-stressed tendons to withstand a 6-million ton iceberg impact. Additionally, a sophisticated ice management program is employed where the platform monitors for, and is alerted of, approaching icebergs. Support vessels are then used to divert the course of any icebergs using ropes or water cannons. The Hebron platform, currently under construction and planned for placement in 95 m of water, has a similar design and incorporates learnings from Hibernia as well as an improved understanding of ice loads. In almost 20 years of operation, Hibernia's ice detection and management system has effectively protected the platform from icebergs.

In deeper water still, 30 km south of Hibernia, the Terra Nova field was discovered in 1984 in approximately 95 m of water and is estimated to hold over 500 million barrels of recoverable oil. Following two additional exploration wells and six appraisal wells, the development plan was finalized in 1998 as a subsea tieback to a floating production storage, and offloading vessel (FPSO). The FPSO was specially designed with a double hull to withstand ice impact and the turret-moored system is equipped for quick release for emergency disconnection in the event an iceberg remains undetected and comes within close proximity to the vessel. Additionally, in case of iceberg scour,[e] the subsea drill centers were installed in mudline cellars and pipelines were buried. White Rose, discovered in 1985, 50 km northeast of Hibernia was also developed using similar FPSO and subsea technologies and remains in operation today, with plans for additional tiebacks to the FPSO under development.

Photo: ExxonMobil.

Figure 1-24. *Hibernia Platform*

United States

Activity in the United States, in parallel with Canada, has pioneered several Arctic drilling and production technologies, with many used as the basis for global Arctic projects today. From the installation of ice-resistant steel piled platforms in Cook Inlet to the use of gravel islands in the Beaufort Sea in the 1960s and the Prudhoe Bay development via the purpose-built 800-mile Trans-Alaska Pipeline System (TAPS) in the 1970s, technology has continued to be developed and deployed. Figure 1-25 highlights the key U.S. Arctic and sub-Arctic oil and gas areas.

Cook Inlet Onshore—First Alaskan Onshore Producing Field

In the early 1900s, the first three wells were drilled in the Cook Inlet region of Southcentral Alaska. Although only one discovered oil, it spurred additional drilling activity in the region. However, high costs, lack of infrastructure, and a short drilling season driven by the difficult Alaska winter created significant challenges. Therefore, serious exploration did not begin until the mid-1950s. Richfield Oil Corporation drilled in the Swanson River region on the Kenai Peninsula and discovered oil in the summer of 1957 and, within a year, Swanson River became Alaska's first onshore producing oil field. Two years later, Union Oil Company of California and Ohio Oil Company made the first major gas discovery in the Cook Inlet area near the town of Kenai. These discoveries led to extensive exploration and production on both sides of the inlet.

North Slope Onshore—Advancements in Arctic Logistics and Pipeline Export

A key to the eventual development of North Slope hydrocarbon resources came as a result of the relationship developed between the Iñupiat and the

e Iceberg scour occurs when the keel of an iceberg comes in contact with the seabed and produces a furrow or scour.

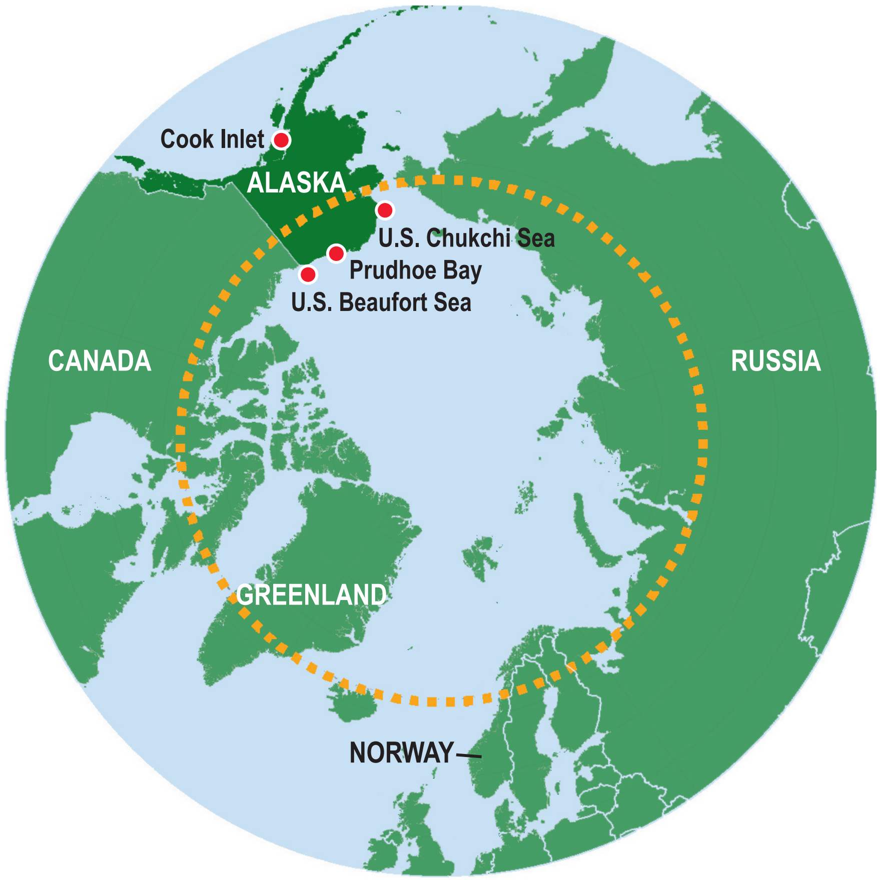


Figure 1-25. *Map of the United States Arctic Highlighting Key Arctic and Sub-Arctic Exploration and Development Areas*

U.S. Navy and USGS in the early part of the 20th century. The Navy/USGS looked to the inhabitants of Arctic Alaska for their expertise and knowledge of their environment, and the Iñupiat looked to the Navy/USGS for a chance at an improved quality of life.

In 1923, with the need for a long-term reliable supply of fuel for the U.S. Navy, President Harding established the Naval Petroleum Reserve #4 (which later became the National Petroleum Reserve in Alaska) on the North Slope. This massive tract of land spans almost 23 million acres,[55] similar in size to the state of Indiana. From 1945 through 1952, dozens of core and test wells were drilled inside and adjacent to Naval Petroleum Reserve #4, resulting in discovery of the Umiat oil field and two small gas fields at Barrow and Gubik.

To complete this work, the Navy/USGS pioneered advancements in exploration and development techniques to overcome many challenges unique to the Arctic environment. Transportation across the tundra provided a particular challenge because summer travel created significant environmental damage, yet travel during the dark cold winter season was not desirable either. As a result, a gravel road design was created that would protect the active layer of the tundra. Another challenge was the presence of permafrost. To support stable civil structures, a system was developed where vertical supports were placed into the permafrost and cemented in place with a slurry of sand and water. This system is still universally used throughout the Arctic.

The Navy/USGS team had a similar learning curve for seismic and exploration drilling in the permafrost environment. Seismic data acquisition in permafrost and over partially frozen lakes presented seismic interpretation challenges. In drilling, after at least one well casing failure, they learned that a nonfreezing fluid (such as diesel fuel or a salt solution) had to remain in the annular space between the surface pipe and interior well casing strings.

This moderated the thaw process that occurred in the permafrost intervals of the wellbore. These innovations remain relevant today and the lessons learned have contributed to the success of America's largest Arctic oil and gas fields.

In June 1968, the largest oil field in North America, Prudhoe Bay, was discovered. However, given the harsh remote and logistically challenged environment, significant time and cost and a viable hydrocarbon export system was needed for its development. Shortly after the discovery, a joint venture was formed to construct an 800-mile overland pipeline to the nearest ice-free port in Valdez. However, before the pipeline could be constructed Native title claims, environmental group opposition, and design and construction challenges all needed to be addressed. After the pipeline was approved in 1973, work continued to address the significant engineering and technical challenges associated with the pipeline's crossing of three major mountain ranges, 800 streams and rivers, and the seismically active Denali fault. Furthermore, to protect the permafrost from melting due to the hot oil flow and to ensure the pipe did not subside, more than half of the pipeline had to be elevated. However, the above-ground design potentially allowed for heat transfer to the permafrost via the vertical support members. Therefore, a passive refrigeration system was created and over 124,000 thermosiphons[f] were installed along the pipeline. Additionally, due to the variations in ambient air temperature (ranging from 50 below to 90 degrees above Fahrenheit), a unique zigzag pipeline configuration was developed to allow for expansion and contraction of the pipeline and allow for movement in the case of earthquakes, as shown in Figure 1-26. This same design is used on the above-ground pipelines on North Slope fields today.

Construction began in 1975 and was completed in 1977, when on June 20 the pipeline went into service receiving its first crude oil from Prudhoe Bay.

In addition to TAPS and infield gathering lines, the development of Prudhoe Bay required a network of roads and well pads to be constructed from locally mined gravel deposits. To help address the high costs of major construction in the Arctic, modularized construction techniques were employed. Large process facilities were constructed in shipyards and other coastal industrial areas and then barged to the North Slope where they were transported via crawler to their site, placed on a piled foundation, and the various modules were connected together. This same technique is still used today.

Photo: Alyeska Pipeline Service Company.

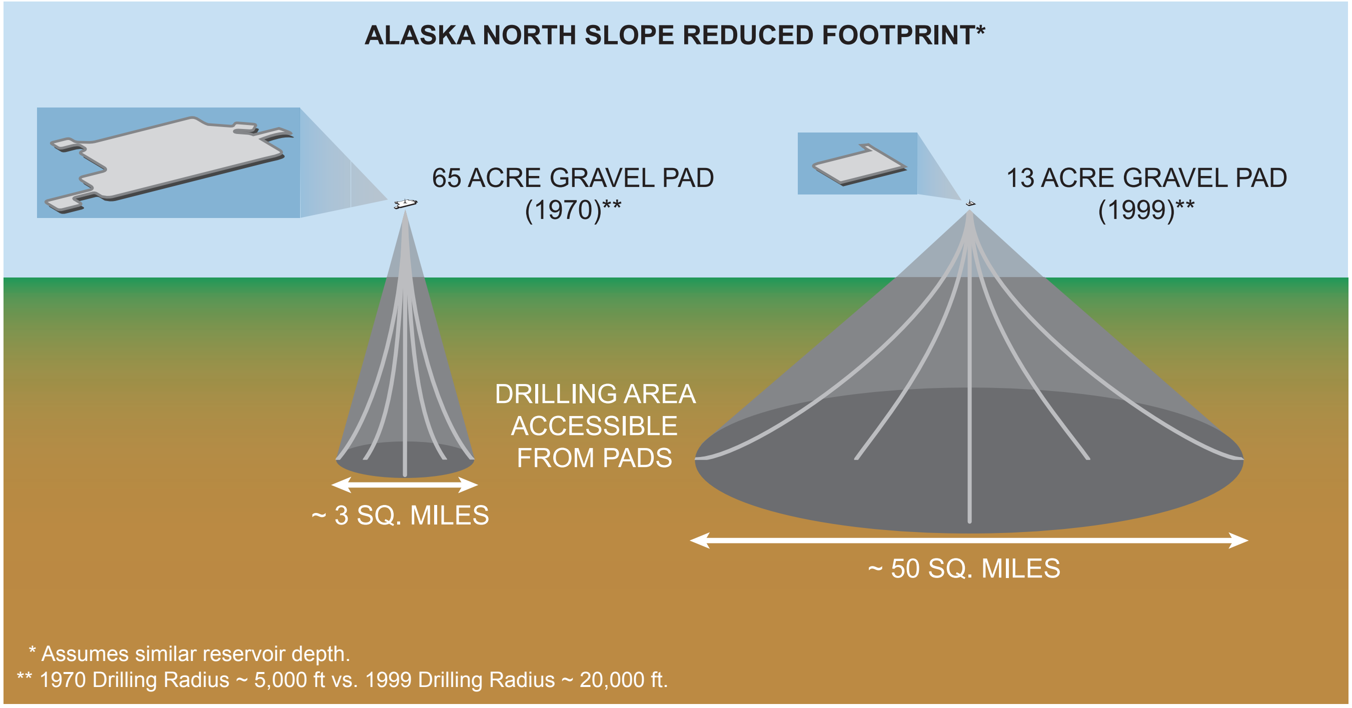
Figure 1-26. *Trans-Alaska Pipeline Zigzag Design*

Currently, the field has six major processing facilities, one of the world's largest gas handling facilities, a gas recompression facility, 38 well pads, over 2,000 wells, a seawater treatment plant, and over 1,000 miles of gathering lines.

Over the past three decades, Prudhoe Bay has been a proving ground for oil field technology that has helped improve recovery. Large-scale gas cycling, water flooding, miscible gas injection, and a technique called water alternating gas injection have been used. Additionally, advanced horizontal and multilateral drilling and advanced well completion methods have been used to reduce the surface footprint of the development. Wells that were once drilled from 65-acre pads in the 1970s are now drilled on much smaller 13-acre pads and, given the significant advances in horizontal drilling techniques, can access more than ten times the subsurface area as shown in Figure 1-27.

Today, Prudhoe Bay remains North America's largest oil field with over 12 billion barrels of production to date, and is among the top 20 oil fields ever discovered worldwide. Prudhoe Bay has historically counted for the majority of Alaska North Slope production. The size of the accumulation has allowed for investments

f A thermosiphon uses natural convection to affect heat transfer instead of using a mechanical pump.



Source: ConocoPhillips.

Figure 1-27. *Improved Drilling Technology to Reduce Surface Footprint*

in infrastructure such as TAPS to be economically attractive and therefore has created opportunities for smaller accumulations to be developed. Today, there are multiple onshore units producing on the North Slope, as shown in Figure 1-28, built upon the technologies pioneered by the Prudhoe Bay development.

The Alpine field in the Colville River Delta to the west became the first North Slope development to be developed exclusively with horizontal drilling technology and thus significantly reducing the surface impact while still allowing access to a 50-square-mile subsurface area. The Point Thomson field, a remote oil and natural gas field currently under development, involves a high-pressure gas condensate cycling project of an offshore reservoir via extended-reach drilling almost 2 miles from shore.

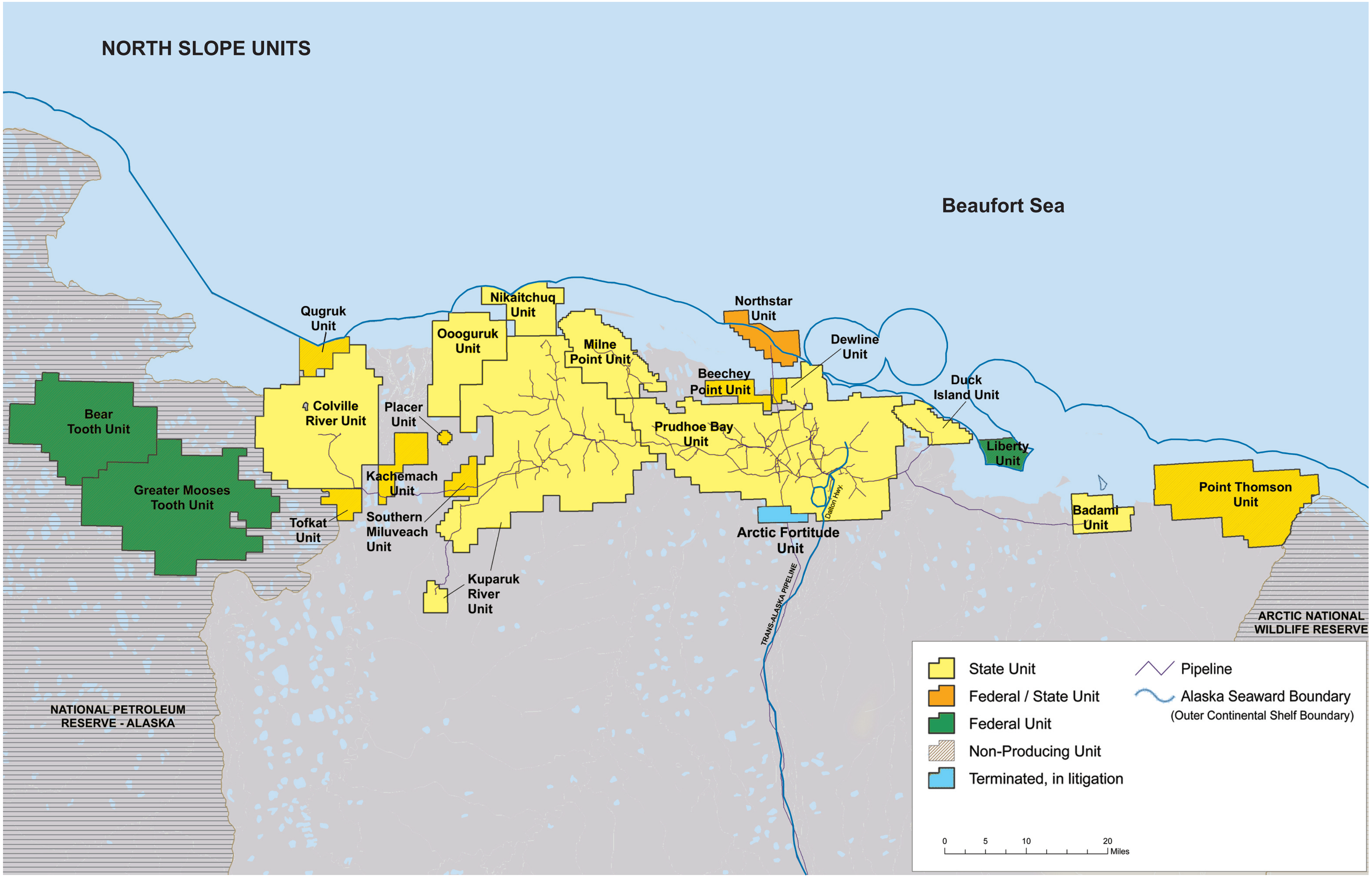
Cook Inlet Offshore—First Steel Piled Platform in Moving Sea Ice

After exploration success onshore Cook Inlet, the next logical step was to explore for hydrocarbons in the offshore region; however, significant challenges needed to be overcome. In addition to long, dark, and cold winters, the inlet hosts tides as high as 30 feet that travel at velocities up to 8 knots. From November to April, the inlet's cold and silty waters are often filled with ice that moves with the tides. In 1962, Pan American Petroleum Corporation discovered the first offshore oil field in the Cook Inlet, at Middle Ground Shoal. The first production platform was installed by Shell in 1964 using a specialized steel platform concept adapted from the U.S. Gulf of Mexico experience to withstand the harsh conditions and strong tidal forces and stop the bridging of the ice between the platform legs.

In all, there have been 16 platforms installed in the inlet with the last production platform installed in 2000.[56] An example of one of these platforms is shown in Figure 1-29.

North Slope Offshore—First Gravel Islands and Mobile Bottom-Founded Structures

Early exploration drilling in the Beaufort and Chukchi Seas began in 1969, with the first gravel islands built in the Beaufort Sea in very shallow water. Shell's Sandpiper Island was, in 15 m of water, the deepest man-made gravel island built. Gravel islands were generally the preferred island construction method in Alaska because of the availability of gravel, as opposed to Canada where only sand was generally



Source: Alaska Department of National Resources, Division of Oil and Gas.

Figure 1-28. *Alaska North Slope Oil and Gas Units*

Photo: Hilcorp.

Figure 1-29. *Cook Inlet Platform with Tower Type Jackets*

available. Figure 1-30 shows the typical construction for these man-made islands.

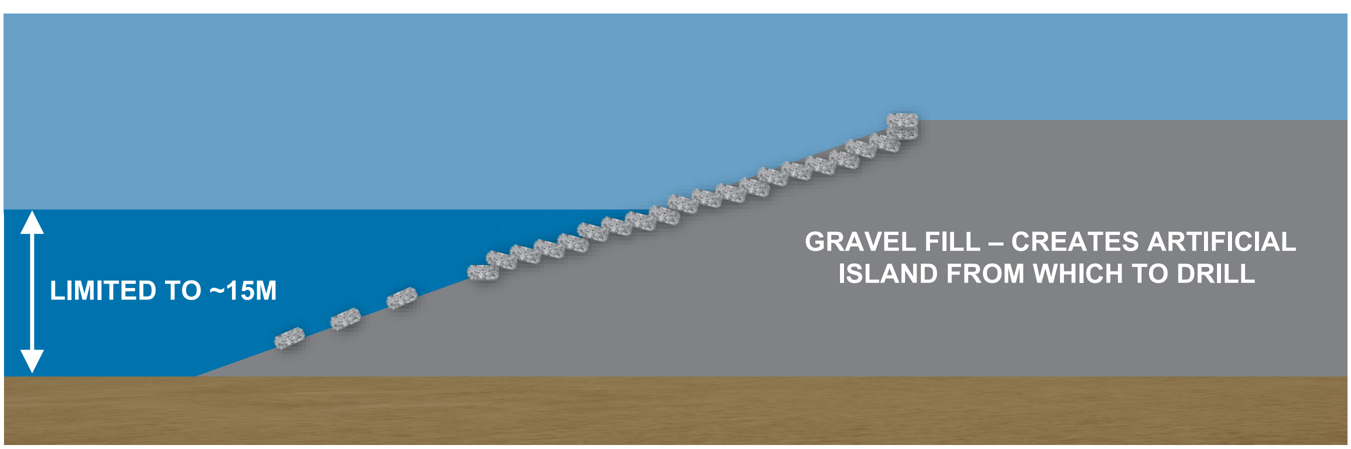
While drilling on ice islands was occurring in the Canadian Arctic, the first well drilled from an ice island in the United States occurred in the 1970s in state waters, 3 km offshore in 3 m of water.[57] As experience grew and gravel and ice island technology was developed, drilling progressed to the deeper federal OCS waters where exploration expanded following the 1979 federal lease sale. Since 1982, a total of 35 wells have been drilled in the OCS using a variety of man-made drilling platforms and ice-strengthened drillships.[58]

In an effort to reduce cost, spray ice islands were also pioneered in the U.S. Arctic and built on earlier experience from the Arctic Islands and U.S. state waters exploration. High-pressure spraying, as shown in Figure 1-31, resulted in considerable reduction in construction times and cost versus seawater flooding. Islands were constructed in 7 m of water in the OCS in 1986 at the Mars prospect, and by Chevron at Karluk prospect in 6 m of water.[59]

As the water depth limitations of ice and gravel islands were reached, a move to gravity-based structures occurred. The first GBS wells were drilled in 1984 by Exxon's Concrete Island Drilling Structure (CIDS). CIDS drilled four wells, the last in 1997. Likewise, Canmar's SSDC/MAT (Single Steel Drilling Caisson with MAT[g]) was used between 1986 and 2003 and consisted of the SSDC used in the Canadian Beaufort Sea with the addition of a new steel base, the MAT, as shown in Figure 1-32.

Moving further outboard into deeper water necessitated floating drill rig solutions, and the first floating wells were drilled by the Shell-Amoco-Union consortium at Camden Bay in 1985.[60] Ultimately, nine wells were drilled in the Beaufort Sea by the *Canmar*

g The MAT was the steel substructure attached to the SSDC to allow use at different locations without the need to build a separate sand berm on the seabed.



Source: Chevron.

Figure 1-30. *Typical Construction of a Shallow Water Gravel Island*

Source: BP – Amoco.

Figure 1-31. *Spray Ice Island Construction*

Photo: G. Timco and I. Morin.

Figure 1-32. *The SSDC/MAT—Now Known as the SDC (Steel Drilling Caisson)*

Explorer II and *Kulluk*, with the last in 1993.[61] The Chukchi Sea has seen less drilling, with exploration starting in 1989 using the *Canmar Explorer II* drillship. Five wells were drilled between 1989 and 1991 by a Shell and Chevron operated consortium.[62]

After discovery in 1978, the Endicott field, located about 3 miles offshore in 6 m of water, was developed in 1985 using two offshore gravel islands connected to shore via a 5-mile causeway. This was the first continuously producing offshore field in the Arctic. As the third major oil field developed on the North Slope, Endicott employed the lessons learned from the construction of Prudhoe Bay and the Kuparuk oil field and used a tight well spacing (10 feet apart) and directional drilling to reduce the surface foot print to about 70% smaller than previous North Slope developments. Additionally, constructing the two islands, a 45-acre main production island and a 10-acre satellite drilling island, and a causeway required the major logistical effort of hauling over 6 million cubic yards of gravel. Furthermore, to address concerns about potential disruption to the migration route of Arctic cisco fish, a bridge was constructed as part of the causeway. Finally, all of the facilities were designed and built to protect against ice, and wave and current erosion. Production began in 1987 and almost half a billion barrels of oil have been produced since then.

After discovery in 1984, the Northstar development, located about 12 miles northwest of Prudhoe Bay in nearly 14 m of water, began in 2001[63] and also employed a gravel island concept. This was the first Arctic offshore field to shore without a causeway. Additionally, Northstar, shown in Figure 1-33, is the only field to produce oil from the federal OCS in Alaska. The self-contained drilling, production, and housing is located on a 5-acre artificial island and is protected from sea ice and wave and current erosion by concrete armor, a steel sheet pile wall, and an underwater bench and berm system. Furthermore, the 6-mile subsea oil pipeline to shore was installed at a depth several feet below the deepest ice gouges ever recorded to protect against possible ice damage. Additionally, to avoid damage caused by strain, the pipeline was built with a wall thickness triple those of typical onshore North Slope pipelines and included three separate leak detection systems. Northstar has produced over 150 million barrels of oil since start-up in 2001.

Following Endicott and Northstar, Oooguruk and Nikaitchuq have been developed with a combination of offshore gravel islands and onshore facilities. The Liberty oilfield, discovered in 1997, is under consideration for development and if it proceeds would be only the second offshore Arctic development in U.S. federal waters.

Russia—First Offloading Terminal and GBS Production North of the Arctic Circle

Given its massive Arctic coastline, Russia has long pioneered developments in icebreaking vessel capabilities and has also established the Northern Sea

Photos: BP p.l.c.

Figure 1-33. *Northstar Island during Winter (left) and Summer (right)*

Route to connect the Pacific and Atlantic Oceans. Additionally, oil and gas production off the coast of the sub-Arctic Sakhalin Island has paved the way for the later development of the Prirazlomnoye field and the Varandey offshore tanker loading terminal. Both of these are north of the Arctic Circle and operate in close to year-round pack ice conditions.

The 1930s saw the beginning of onshore Russian Arctic oil and gas exploration in the remote Yamalo-Nenets region of the Soviet Union. This was followed by several large onshore discoveries across the Russian Arctic in the 1960s, with extensive development and the start of production in the 1970s. Similar to other Arctic locations, development was challenged by permafrost and the distance to market. Despite this, over 6 billion barrels of oil and 550 TCF of gas have been produced to date, with production concentrated onshore western Siberia.[64]

Significant activity has also occurred in the Russian Arctic offshore, and in 1988 the Shtokmanovskoye gas field was discovered. The only offshore development is Gazpromneft's Prirazlomnoye in the Pechora Sea, discovered in 1989 and estimated to have over 350 million barrels of oil.[65] Development of the field was achieved with the first manned offshore gravity-based platform north of the Arctic Circle. This is a significant historical achievement considering ice coverage can last up to 10 months of the year with temperatures dropping to –60 degrees Fahrenheit. Production from Prirazlomnoye commenced in late 2013, with oil exported via ice class tankers. Figure 1-34 highlights some of Russia's Arctic and sub-Arctic oil and gas areas.

Although south of the Arctic Circle, Sakhalin Island located north of Japan has been home to several developments in Arctic-like ice conditions over the past 20 years. Sakhalin-1 includes the offshore shallow water Arkutun-Dagi, Chayvo, and Odoptu fields and, after discovery in the 1970s and 1980s, the fields have been developed in phases starting in the late 1990s. Chayvo, developed first, uses both an offshore drilling platform that is one of the largest ice-resistant concrete substructure platforms ever constructed and extended-reach wells drilled from an onshore drilling pad. The platform design allows it to operate year-round in ice-prevailing waters that can experience ice ridges more than 30 m in thickness. Additionally, the onshore drilling rig has achieved record-breaking drilling with the longest extended-reach well ever drilled at almost 13 km.[66] Odoptu followed, using the Yastreb rig to drill extended-reach wells to the offshore reservoir. The Arkutun-Dagi field, in its final stages of development, is the first of its kind to use friction pendulum bearings and a design to withstand both ice impact and earthquakes of magnitude up to 9.0.[67] The oil from all of these fields flows back to onshore processing facilities before being carried via pipeline to an export terminal at Dekastri. Tankers are loaded year-round and escorted by icebreakers as required through the Tatar Strait. In 2009, the Dekastri Terminal was named Terminal of the Year at the oil terminal conference in St. Petersburg, voted by

Figure 1-34. *Map of Russian Arctic Highlighting Key Arctic and Sub-Arctic Exploration and Development Areas*

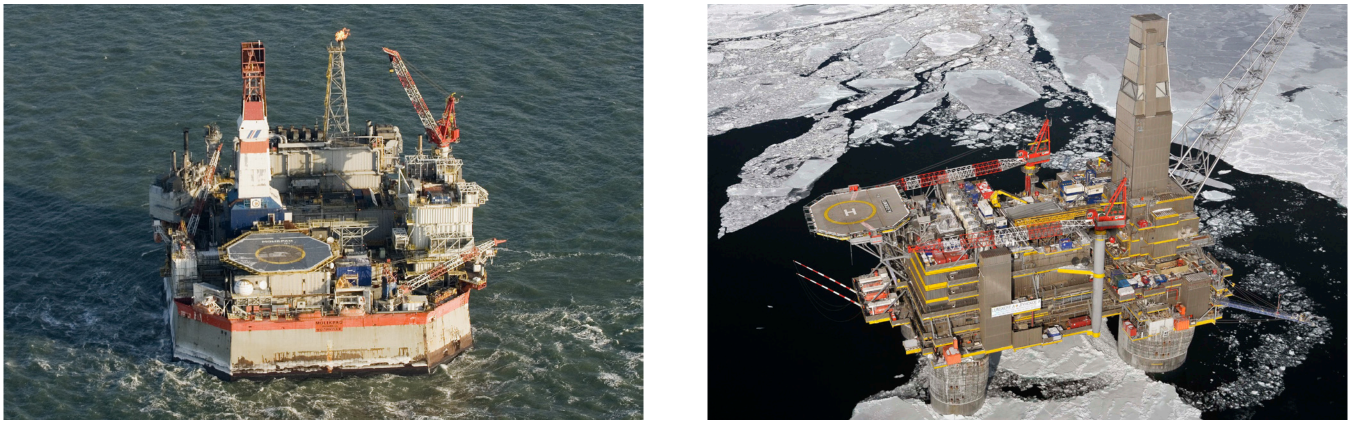
industry and experts for its efficiency in such areas as economics, environmental, and social.

Sakhalin-2 comprises two major field developments: Piltun-Astokhskoye oil and gas field to the north and Lunskoye gas condensate field to the south. Similar to Sakhalin-1, both are in shallow water off the east coast of Sakhalin Island. These fields were discovered in the mid-1980s. The first phase targeted early oil production from the Piltun-Astokhskoye field by converting the Molikpaq caisson, as shown in Figure 1-35, to a fixed drilling, production, and quarters platform and using a floating export and offloading system and tanker export. Seasonal production from this system commenced in 1999. Phase 2 began after this early production system was decommissioned in 2008. The second phase included year-round production from two new platforms, with production transported via subsea pipelines to the onshore processing facility. Then, two 800-km onshore pipelines feed LNG facilities and an oil export terminal at the south of the Island. The LNG plant, located in Prigorodnoye, is the first of its kind in Russia, with two trains for a combined production capacity of almost 10 million tonnes per annum. LNG is transported via ice-strengthened ships designed to operate in very low temperature year-round.

Sakhalin-3 is the third set of developments on the island and is located to the south of Sakhalin-1 and Sakhalin-2. The fields in this gas development were discovered between 1992 and 2011. The development of Sakhalin-3 will also be in phases beginning with the Kirinskoye block, located in water depths averaging 100 m to 250 m with ice coverage several months of the year. A subsea tie-back 29 km to shore, the first of its kind in Russia, has been constructed to deliver gas to Russia's mainland. Production commenced in 2013.

Norway—First Subsea to Shore LNG in the Arctic

Norway has developed many Arctic technologies with a historical focus on subsea production, given the countries long coastline and deep seas. Additionally,



Photos: Sakhalin Energy.

Figure 1-35. *Molikpaq (2006) (left) Converted for Early Production and Lunskoye-A GBS at Sakhalin-2 (right)*

the long open water season has enabled deeper water developments compared to other Arctic regions. Norway developed the world's first subsea to shore gas development in Arctic waters. Development of the Snøhvit field has allowed for commercialization of offshore deepwater Arctic gas using onshore LNG facilities designed for cold Arctic temperatures.

Norway has a long history of offshore oil and gas development, with over 100 exploration wells drilled in both Arctic and sub-Arctic areas since exploration activity started in the North Sea in the mid-1960s followed by activity in the Barents and Norwegian Sea in the late 1970s. Barents Sea drilling had limited success with many of the discoveries being gas and not large enough to commercialize given the distance to markets. Some of these discoveries (Snøhvit, Albatross, and Askeladd) were declared commercial in 2004, and production started in 2007. Snøhvit, shown in Figure 1-36, was the largest of the three and the first field in Norway's Arctic to be developed without any offshore surface structures. It is located 140 km from shore. Subsea wells flow gas through pipelines to Melkøya, outside Hammerfest, where the first LNG export plant in Europe processes the gas. Figure 1-37 highlights some of Norway's Arctic and sub-Arctic oil and gas areas.

Exploration activity has increased significantly in recent years, and several large discoveries have

Photo: Statoil (Harald Pettersen).

Figure 1-36. *Snøhvit LNG Facility near Hammerfest, Norway*

Figure 1-37. *Map of Norwegian Arctic Highlighting Key Arctic and Sub-Arctic Exploration and Development Areas*

been made. The Goliat field was discovered in 2000, with production scheduled to start in 2015. Additionally, the Johan Castberg field is currently under development, and Wisting is currently under evaluation for potential development. Furthermore, in 2014 a number of wells were drilled in the Hoop area and are some of the northernmost wells ever drilled. Development of these fields will encounter similar challenges to other remote offshore Arctic locations.

Greenland—Exploration Has Begun in One of the Most Challenging Arctic Environments in the World

Since the 1970s, there has been varying levels of interest in Greenland's offshore potential. In the early 1970s, exploration focus was on the western offshore region where five wells were drilled in 1976 and 1977 without a discovery. In 2000, another well was drilled in the region with similar results and, again in 2011 and 2012 additional wells were drilled with no significant discovery reported. With waning interest on the west coast in Baffin Bay, recent lease sales were awarded in 2013 on the northeast coast.

Northeast Greenland offshore is considered by many as one of the harshest Arctic environments in the world. Almost year-round multi-year ice, fast ice floes, and icebergs and ice islands traveling from the north provide for a complex operating environment. Although the northeast is considered to have significant oil potential, only seismic surveys have been completed to date, with exploration drilling and development yet to occur. Figure 1-38 highlights some of Greenland's Arctic and sub-Arctic oil and gas areas.

What Lies Ahead—Continued Development of Arctic Technologies

As exploration and development continues, technology development is expected to continue to progress and enable prudent exploration and development in more challenging Arctic environments. Below are just a few examples of recent or planned major activities in the Arctic.

In the summer of 2014, ExxonMobil and Rosneft commenced exploration drilling of the Universitetskaya-1 well in the south Kara Sea, an area more than 125 thousand sq. km with water depth ranges from 20 m to 200 m. Drilling began in August 2014 with the West Alpha semi-submersible rig, and it is the Russian Federation's northernmost well.[68] Given the harsh cold and icy environment, the West Alpha was upgraded and winterized to withstand temperatures as low as –50 degrees Celsius and a sophisticated ice management system was employed to ensure continued safe drilling operations. The well was successfully drilled to total depth in October 2014.

Novatek's Yamal LNG project will develop the massive South-Tambeiskoye gas condensate field near Russia's Yamal Peninsula. Discovered in 1974 and estimated to hold 25 TCF of gas and 210 million barrels of condensate, the plan is to build a three train, 15 million tonnes per annum LNG facility and produce from approximately 210 production wells. Plant facilities and additional infrastructure including a 375-megawatt power plant will be designed to withstand the extreme winter conditions. Additionally, approximately 16 ice class, world-scale LNG tankers will be specially designed and built to manoeuver through waters with ice 2 m thick and transport LNG from Yamal to markets in Asia via the Bering Strait during the summer and fall, and to Europe via the Kara and Barents Seas year-round. Currently, Yamal LNG is expected to start up around 2017 and will mark one of the largest developments in the Arctic.

Also in Russia, Shtokmanovskoye (Shtokman) is one of the largest global gas discoveries made. It is located in Arctic waters 300 m to 350 m deep and approximately 550 km from the coast of the Russian Kola Peninsula. Discovered in 1988, the field is estimated to hold almost 95 TCF of recoverable natural gas and 300 million barrels of condensate.[69] A three-phase development has been proposed, with Phase 1 to include subsea wells tied back to an offshore floating production unit, with processed gas sent to an onshore LNG plant before being exported via pipeline. Condensate would be loaded offshore to tankers. Phase 2 and 3 would expand LNG capacity. The major technical challenges for this development include the short open water season, large icebergs, severe storms, earthquakes, and subfreezing temperatures that occur most of the year. Development is

Figure 1-38. *Map of Arctic Greenland Highlighting Key Arctic Exploration Areas*

currently on hold to finalize commercial agreements; project start-up is not expected before 2030.

In the United States, the proposed Alaska LNG project is another major undertaking in Arctic gas development. Since the discovery of Prudhoe Bay in 1968 and Point Thomson in 1977, about 35 TCF of gas have been stranded on the North Slope due to a lack of a gas export infrastructure. While there have been a number of proposals over time, they have not been economically viable given the high cost of construction. Recently, a consortium made up of the three major North Slope producers, the state of Alaska, and a Canadian pipeline company has advanced plans for a proposed $45 to $65 billion project[70] to enable the development and commercialization of that North Slope gas. The project would take gas from the Prudhoe Bay and Point Thomson fields to a new world-scale gas treatment plant on the North Slope where around 3.5 billion cubic feet of gas per day would be treated (including removing the CO2) before being delivered to a new large-diameter, 800-mile long natural gas pipeline to the liquefaction facility presently planned for the Kenai Peninsula. It is expected that the pipeline will face many of the same challenges as TAPS; however, the gas will be chilled and the pipeline buried in areas of permafrost. The liquefaction facility is planned to have three trains capable of producing about 20 million tonnes per annum. Loading facilities and ships will be designed to contend with the large tides and the winter ice floes of the Cook Inlet.

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Chapter 2

Development Potential and Challenges

SCOPE

This chapter provides an overview of the different Arctic physical environments and outlines the elements of prudent Arctic exploration and development. Topics covered include a general description of the global ice environment followed by a high-level discussion of the key drivers for economic prudent exploration and development. A discussion of the factors that result in high cost and long timelines for exploration and development in the Arctic is provided, including an outline of typical timelines from lease sale to production. A general description of the typical drilling, production, and oil and gas transport options as well as Alaska focused logistics considerations is provided, including how the various physical Arctic environments impact the ability to explore and develop both globally and in the U.S. Arctic.

INTRODUCTION

The Arctic is a different environment often distinguished by the presence of ice and its general remoteness. Polar nights bring periods of up to 24 hours of darkness during the winter months with continuous daylight in the summer. Year-round ambient temperatures are generally low and mostly well below freezing. Arctic operating conditions can vary substantially from country to country, basin to basin, and even year to year. Differences in the physical operating environment can impact the complexity associated with exploration and development activities. Compared to other global oil and gas locations, to prudently explore and develop in the Arctic requires many different technologies, significant investment, and long timelines. Quality oil and gas resources of sufficient size are required from exploration programs to enable economic and prudent development. While there are a number of different aspects of the physical environment that can impact prudent exploration and development, the predominant aspect is ice type and abundance, with water depth and the length of the open water season also important.

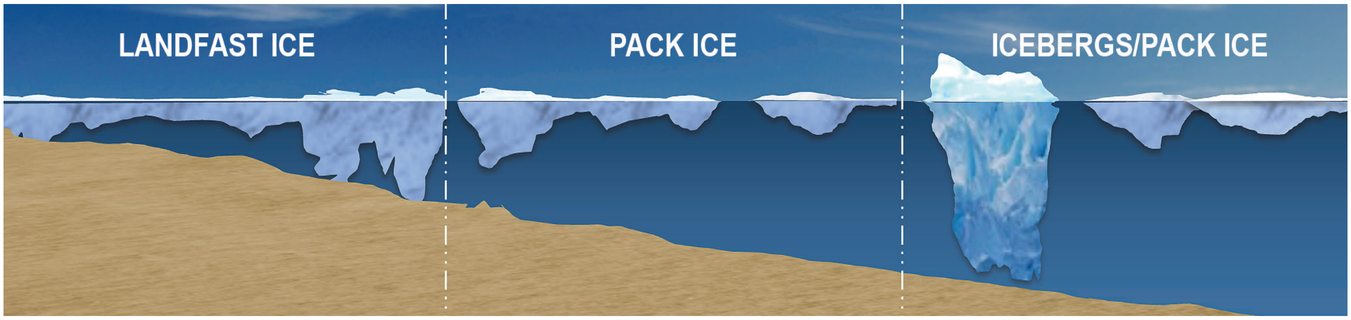
THERE IS NOT ONE ARCTIC PHYSICAL ENVIRONMENT

Ice Environment

The first key parameter is ice type and abundance. The typical ice regimes found in the Arctic are landfast ice, pack ice, and icebergs/pack ice, as shown in Figure 2-1. Ice type and concentration impacts the forces on vessels and platforms as well as the ability to maneuver for operations.

Arctic seas can contain several different ice types. Examples can be seen in Figure 2-2.

- The open water season occurs during the summer melt season when there is essentially no pack ice cover (technically, it is when pack ice covers less than one tenth of the area). Open water season length can vary substantially from year to year.
- Landfast ice occurs when the water near the coastline freezes, attaches to the shoreline and seafloor, and is relatively stable.
- Pack ice is concentrated, mobile sea ice cover. Pack ice compresses under the force of changing wind direction and deforms to form thickened ridges and rubble fields. Pack ice is generally characterized according to its age, which relates directly to thickness and strength:
  - First-year ice is new ice that forms over the open water each winter.



Source: Chevron.

Photo: NASA. Photo: ExxonMobil. Photo: ION Geophysical.

Figure 2-1. *Typical Arctic Ice Regimes*

- – Second-year ice is thickened ice resulting from refreezing of surviving first-year ice from the previous season.
- – Multi-year ice is thick ice built up from multiple freeze cycles of previous years' ice.
- Icebergs are large freshwater ice masses that break off from glaciers and drift with sea currents.
- Ice islands are massive tabular ice floes that break off from multi-year ice shelves or glaciers and drift within pack ice.

In the U.S. Arctic, under the current climatology of diminished summer ice extent, landfast ice and first-year ice are the most common ice types. However multi-year ice also occurs. Historically, icebergs do not occur in the U.S. Arctic and ice islands are rare occurrences.

Water Depth

Water depth is the second key variable in determining the types of drilling rigs and production systems for exploration and development. In shallower waters, drilling from shore or man-made islands can be used. With increasing water depth, bottom-founded solutions, followed by floating solutions are required. Bottom-founded solutions can be used in water depth

Photos (from left): ExxonMobil (1,2,3); CANATEC (4).

Figure 2-2. *(Left to right) First-Year Ice with Numerous Pressure Ridges and a Rubble Field in the Foreground; Multi-Year Ice Ridge in the Canadian Beaufort Sea; Iceberg Approximately 200 m Across; 6 km Ice Island Fragment Embedded in First-Year Sea Ice* up to approximately 100 meters (m) depending on local seafloor and ice conditions for both drilling and production. Beyond 100 m subsea or floating solutions are required for production.

Open Water Season

The open water season is the third key parameter that has a significant impact on the types of technologies used and on executing plans for offshore activities. The length of the open water season impacts the ability to conduct ice-free operations in a timely and efficient manner. In general, short open water seasons can restrict access and require additional time and investment to complete various activities such as drilling a well or installing facilities. Longer open water seasons generally allow for more activities in a given year. Open water also allows for the use of floating drilling rigs for depths greater than approximately 20 m. As noted elsewhere in this report, most of the U.S. Arctic undiscovered conventional offshore resource potential is in depths up to approximately 100 m and in general has an open water season of greater than a few months.

KEY DRIVERS FOR ECONOMIC PRUDENT EXPLORATION AND DEVELOPMENT

Before progressing new prudent exploration and development, it is first necessary to understand what has been accomplished to date with existing technology, and then to define the key drivers that facilitate safe and efficient exploration and development in an Arctic setting. Without exploration and discoveries of sufficient quality to justify significant investments, there can be no development. Thus it is vital to examine the key drivers for exploration and development separately. Figure 2-3 illustrates the five key stages for an oil or gas development. While this is shown as a linear set of activities for illustrative purposes, seismic acquisition and subsurface mapping can and will usually start well ahead of a lease sale.

Elements Required to Enable Prudent Arctic Exploration and Appraisal

Several elements are required to support Arctic exploration. Generally, exploration may proceed if there is uncertainty in one or two of the following elements, but the likelihood of exploration activity occurring is reduced as the uncertainty increases. The following outlines the key elements to the exploration and appraisal phases.

- **Resource Potential:** An area must show resource potential to attract interest. As documented in Chapter 1, there is estimated to be substantial oil and gas potential in the U.S. Arctic, both onshore and offshore.
- **Access to Acreage:** Lease sales are a prerequisite for exploration. In the United States, companies purchase the right to access lands for exploration and development by bidding in lease sales with the lease awarded to the highest bidder. The frequency of lease sales and the areas offered are determined by the government.

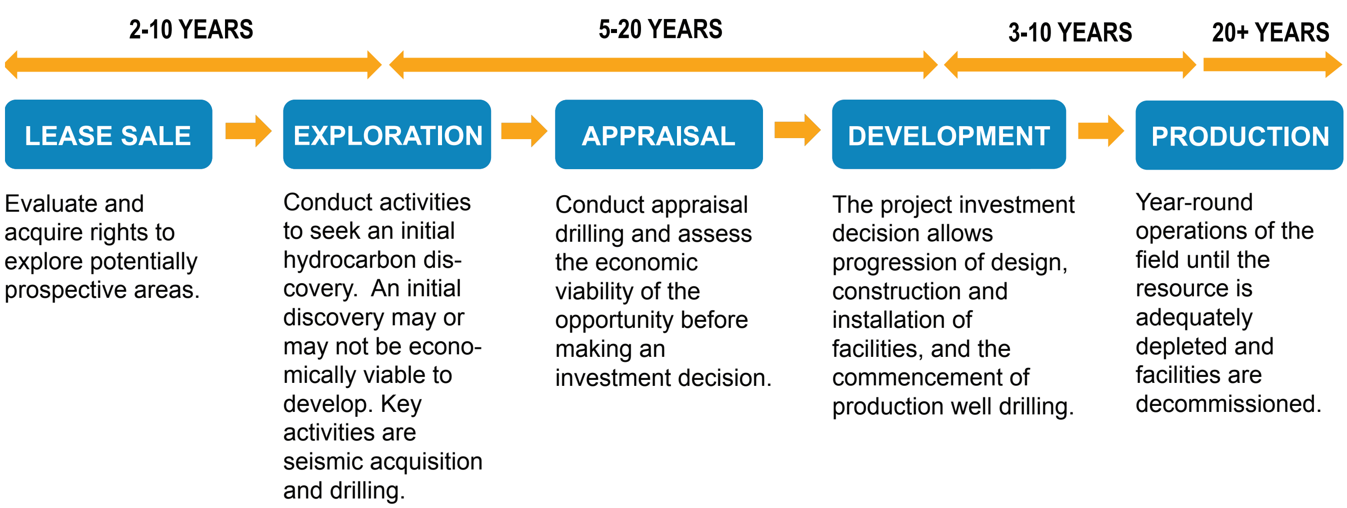


Figure 2-3. *Typical Stages of an Oil or Gas Development*

- **Lease[a] and Fiscal Terms and Conditions:** Lease terms and conditions are a major consideration when entering a new area. This is especially the case in remote high-cost locations with limited access such as the Arctic. Companies seek adequate time to carry out an exploration and appraisal program, the ability to retain a discovery until economics justify development, and appropriate fiscal terms that support economic development.

- **Stakeholder Alignment:** To enable exploration, a consultation process is required involving the demonstration of mutual benefits to, and meaningful engagement and participation of, local residents, regulators, and operators as partners in the resource development. This alignment grants the partners a license to operate.

- **Regulatory Alignment and Predictability:** A regulatory framework with clear process and timelines is needed to attract investment in high-risk exploration activities. Permits are also required for a variety of activities before they can commence, including conducting seismic acquisition and drilling wells.

- **Environmental Assessment:** A key precursor to exploration is a comprehensive environmental assessment to highlight any potential positive or negative impacts that drilling operations may have on the area and, if required, how any negative impacts would be mitigated. Local stakeholders, industry, and the regulator should be involved in such an assessment, thus ensuring that all issues are clearly understood before the acreage is acquired and exploration commences.

- **Expectation of Economic Viability:** It is a normal practice for industry to carry out an economic prescreening of any new exploration prospect to ensure that it ranks favorably within the portfolio of exploration opportunities available to the company. Such assessment in an Arctic setting would involve a high-level screening economic assessment as well as consideration of the challenges and costs associated with key exploration activities such as seismic acquisition and drilling.

Once the above elements have been satisfactorily addressed, and presuming a decision to bid is made and leases are won and awarded, the exploration operational phase begins. This phase requires continued progression of the elements listed above. However, the focus shifts to operations readiness and execution of the exploration program, and drilling proceeds only if it is safe to do so and after the well has been designed for safe operations.

- **Understanding the Local Physical Environment:** An understanding of the physical environment is fundamental to planning and conducting any activities. Ice conditions can drive seismic and data gathering activities as well as the drilling system that can be used, including the drilling unit, marine support vessels, oil spill response, ice management vessels, and emergency escape and rescue systems. Additionally, the physical environment drives the methods and timing by which equipment is mobilized to and from site and the length of time operations can safely occur. Moreover, water depth and seafloor and soil conditions all need to be considered when planning exploration activities.

- **Logistics:** The ability to move vessels, equipment, people, and supplies into an area are important factors in determining the time and cost of exploration and development activities, especially for remote, harsh environments such as the Arctic where access can be severely limited. In the U.S. Arctic, limited infrastructure, long distances, and the type and abundance of ice are the three factors that most influence the ability to move to, from, and within the area being explored.

- **Emergency Preparedness:** Exploration and development can prudently occur with a plan and appropriate equipment and people in case of emergency. Emergency evacuation and response and oil spill prevention and response are key elements to any exploration or development activity. The proposed plan and equipment need to adequately support the operations to be undertaken and meet local stakeholders and regulators expectations and requirements.

- **Acquire Additional Data:** The first few years of most leases are dedicated to planning and approvals for the seismic acquisition program and gathering data such as local soil conditions. The physical operating environment will have an impact on the availability of appropriate seismic acquisition vessel and support craft, which, in turn, can impact the schedule. In addition, there are often blackout periods

a Lease is the term used in the United States; other countries use land or license.

where seismic acquisition is not permitted—these are often related to marine mammal migration or harvesting activities.

- **Stakeholder Alignment and Regulatory Approvals:** To maintain stakeholder alignment and acquire the required regulatory approvals, it is critical to continue the productive dialogue that started in the exploration planning phase. This continues to form the license to operate.
- **Drilling the Well(s):** Once all of the above is in place, drilling of the well(s) can occur. To provide sufficient information for the operator to determine the size and the quality of any discovery, an initial exploration well, followed by several appraisal wells, is usually needed. Furthermore, data gathering and flow testing of the well are also often required.

As illustrated, there are several elements to the process, including deciding to conduct, planning for, and executing an exploration program with no guarantees of making a discovery or of it being economic to develop. The exploration operations usually last for several years.

Elements Required to Enable Prudent Arctic Development

Having completed a successful exploration program, made a discovery, and delineated it, an operator now moves into a phase to define development viability and subsequently moves to development if justified. A great number of factors can influence the economic viability of a proposed development. Following are some of the key elements most likely to influence a successful development in the Arctic.

- **Discovery of a Material and Quality Resource:** For development viability, exploration must first result in a discovery. Once discovered, the size, density, and quality of the resource are all critical in determining materiality and if and what type of development may be appropriate. The resource needs to be of significant size (barrels of oil equivalent) to justify the substantial time and expense to develop it. The resource density (spatial compactness) can drive the number of wells and number of production systems needed. The quality of the resource also drives the number of wells. All three collectively impact the economic viability of any proposed project to develop that resource.
- **Development Concept:** This involves an assessment of the alternatives available to prudently develop the resource. The elements of this assessment often include analysis of markets and fiscal terms and agreements, designing an appropriate depletion and drilling plan for the reservoir, assessing environmental impacts, understanding infrastructure and logistical needs, the use of appropriate technologies, and the type of production and export systems to be used. This usually culminates with a detailed cost and schedule being developed from which the economic viability of the different development options is assessed. Once a preferred concept has been chosen, front-end engineering design (FEED) is undertaken to further define the project scope, followed by detailed design.
- **Expectation of Economic Viability:** Given the already high cost to develop in the remote Arctic, a resource of sufficient size, density, and quality is needed to justify the cost and time to invest in the right development concept. Operators require an expectation of economic viability before committing the significant financial and other resources required to execute such large-scale projects. Additionally, it is important to note that even when a discovery has been made and a feasible development concept is available, market and economic conditions still may determine whether there is an economically viable project to proceed at that time.
- **Stakeholder and Regulatory Alignment:** It is critical to continue engagement and secure regulatory and other approvals throughout this phase to ensure a license to operate is maintained and permits for specific activities are granted.

Once the above elements have been satisfactorily addressed, a decision to develop has been made by the operator, and required approvals and stakeholder support obtained, the full field development operational phase begins. Given there are several overlaps with the exploration operational phase, the following key differences are highlighted.

- **Logistics and Infrastructure:** Setting up the air and marine supply routes, ports, airstrip, staging areas, roads, and camps for an onshore base to support full field development in a new area is a significant endeavor. Depending on location, supplies may be delivered to a supply base by vessels in the open water, vessels operating in ice, or by overland methods. Preplanning and logistics become critical to the success of a project. For example, the open water supply window is relatively narrow and a full year of operations may be lost if the bulk materials or major equipment needed for the following year of operations are delayed by a few weeks and miss the open water delivery season.

- **Increased Activity:** The primary development activities—drilling, completions, pipeline and facilities construction, production operations, and product export—will overlap and require numerous supply and support vessels. Maintaining a focus on safety, environmentally responsible operations, and local impact is paramount when coordinating simultaneous operations.

- **Year-Round Operations:** While exploration activities can be conducted seasonally, full field development of a major resource will require sustained year-round production and product export. Policies and regulations that support a year-round operating season must give consideration to environmental protection, prudent ice management, and personnel protection systems.

DEVELOPMENT SCENARIOS AND TYPICAL TIMELINES

Exploring for oil and natural gas deposits in the Arctic, though technically achievable, is expensive, and once discovered it will be challenging to commercially develop a given discovery. As is common in remote areas, large fields are required to shoulder the economic burden of the front-end infrastructure needed to enter a new region. For example:

- **Prudhoe Bay Onshore Oil:** Discovered in 1968, Prudhoe Bay field had a recoverable oil estimate of 9.6 billion barrels at the time, and the initial feasibility study estimated a cost of approximately $1 billion for the pipeline and oil export terminal. The owners, including Amerada Hess, ARCO, Sohio, Exxon, Mobil, Phillips, Union Alaska, and BP, formed the Alyeska Pipeline Service Company to design, build, and operate the Trans-Alaska Pipeline System (TAPS). As the design progressed the estimate was updated, and by the start of construction in 1974 the estimated cost was approximately $4 billion. By the end of 1977, the final cost was closer to $8 billion.[1]

- **North Slope Onshore Gas:** The Prudhoe Bay oil discovery in 1968 also found an estimated 26 trillion cubic feet (TCF) of natural gas. An additional 8 TCF of gas was discovered at Point Thomson in 1977. Federal and state legislators have enacted numerous laws to spur on natural gas development, and various joint venture partnerships have explored alternatives for bringing this gas to market, but 40 years later it remains a stranded resource.

The North Slope examples above demonstrate the very large resource size and long development timelines needed to bring the initial onshore Arctic oil fields and infrastructure from discovery to production. As exploration moves offshore into more challenging operating environments and the distance from existing infrastructure increases, the threshold for quantity and quality of hydrocarbon resource required for commercially viable developments will also increase. After an initial development in a basin or region, there is a reasonable expectation that projects might use some of the existing infrastructure and therefore shorter timelines may result.

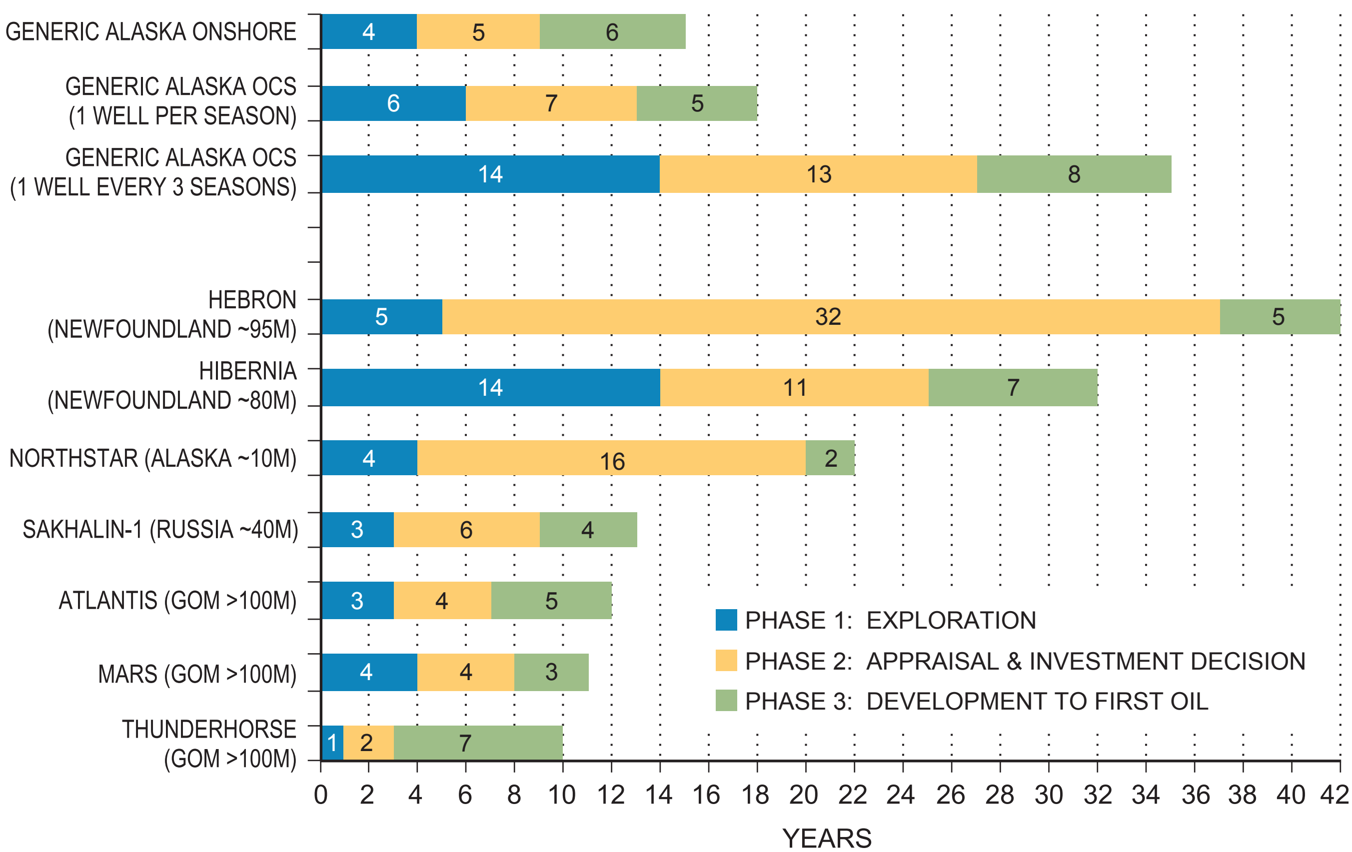
Once major infrastructure is in place for an anchor field, it often becomes feasible to develop smaller adjacent fields. However, smaller is a relative term, and still means very large satellite fields are required for follow-on development in the Arctic. The Kuparuk field discovered in 1969 had an originally estimated recoverable oil resource volume of 1.6 billion barrels and started production in 1981. The Alpine field discovered in 1994 had an originally estimated recoverable oil resource volume of 500 million barrels and production commenced from this field in 2000. If either of these fields had been discovered before Prudhoe Bay, it is unlikely they would have been economically viable to develop at that time. Proximity to TAPS is likely to continue driving oil development in Alaska, provided that areas are made available for exploration. As the distance from existing infrastructure increases, the threshold resource size required to bear the burden of additional tie-in costs also increases.

Development Timeline Summary

The seasonal nature of activities in remote Arctic regions imposes a significant burden on the development timeline making it extremely difficult to complete the basic exploration and appraisal activities to demonstrate a commercial discovery within the 10-year primary lease term, as discussed in Chapter 4, let alone commence production. Figure 2-4 highlights the long timelines for several completed global Arctic and sub-Arctic oil projects and compares them to select Gulf of Mexico (GOM) projects and generic Alaska Arctic timelines. The assumptions behind these generic offshore timelines are discussed below.

Phase 1: Oil and Gas Exploration—Lease to Initial Discovery

Activities in the exploration phase are primarily directed towards obtaining seismic data and drilling exploration wells. Planning the seismic program, contracting the equipment or vessels, gathering the seismic data and interpreting it to identify potential drill sites, could require 3 to 5 years of the initial lease



Year of Activity	Atlantis GOM >100 m	Mars GOM >100 m	Thunderhorse GOM >100 m	Sakhalin-1 Russia ~40 m	Northstar Alaska ~10 m	Hibernia Canada ~80 m	Hebron Canada ~95 m
Initial Lease Sale	1995	1985	1998	1974/ 1995*	1979	1965	1975
Discovery	1998	1989	1999	1977	1983	1979	1980
Project Investment Decision	2002	1993	2001	2001	1999	1990	2012
First Oil	2007	1996	2008	2005	2001	1997	2017

* Sakhalin-1 (Chayvo) discovered in 1977. Production Sharing Agreement signed in 1995 after ownership disputes resolved.
Note: Geographical location and approximate water depth of the development shown with the project name.

Figure 2-4. Summary of Typical and Actual Timelines for Arctic and Sub-Arctic Projects Compared to Gulf of Mexico (GOM) term, as discussed later in Chapter 4. While some seismic data can be, and often is, acquired before a lease term begins, in a frontier area, it is likely that additional seismic data will be needed. Additionally, a survey of shallow hazards at the potential drilling area is needed. A similar time frame (not shown in Figure 2-5) is required for planning the exploration drilling program, contracting for (and perhaps modifying or building new) drilling systems complete with ice management, and contracting for the support vessels required to conduct exploration drilling. Operating within current regulatory boundaries in the limited open water season, as discussed later in Chapter 4, in the Chukchi Sea, a reasonable assumption would be one well per season for a shallow target depth, with this easily extending to one well in two or three seasons for deeper targets in deeper water with shorter open water seasons. This is shown in Figure 2-5. However, for targets in less than 100 m of water in the U.S. Arctic, it is anticipated that one to two seasons would likely be sufficient to drill a well. For onshore or in landfast ice regions, it is unlikely that more than two exploration wells could be drilled in a single season. Well testing would likely require an additional season.

These typical exploration timeline scenarios assume that three prospects are explored and one hydrocarbon discovery is made. They show the broad range of time that may be required just to conduct the primary seismic acquisition and conduct exploration drilling activities in the exploration phase. Furthermore, this does not account for the time that may be required to conduct, either in series or parallel, activities such as environmental studies, stakeholder engagement, or shallow hazard assessments, which are all prerequisites for obtaining the permit to drill. The projects listed in Table 2-1 highlight this variability in timelines for the exploration phase for a variety of Arctic and sub-Arctic basins.

Exploration drilling is not always successful, even where there is strong indication of resource potential. There were 11 exploration wells drilled on the North

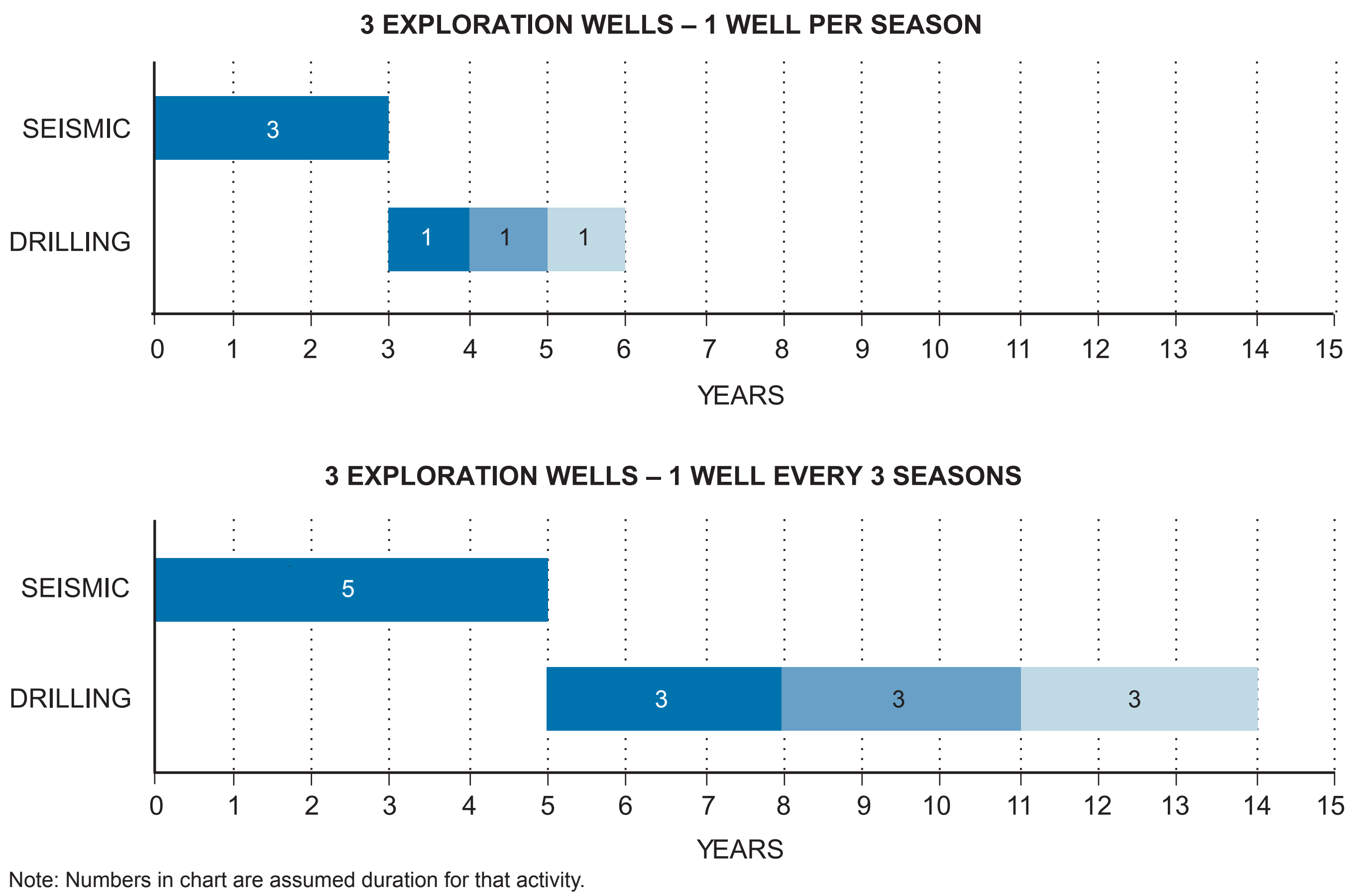


Figure 2-5. *Phase 1: Typical Alaska OCS Exploration Timeline Scenarios*

Exploration Examples	Water Depth (m)	Exploration System	Year of Lease Acquisition	Year Discovered	Time from Lease to Discovery
Northstar, Beaufort OCS, Alaska	10 to 15	Artificial Island	1979	1983	4 years
Point Thomson, Alaska North Slope	Onshore	Land Rig	1965	1975	10 years
EL 476/477, Beaufort Sea, Canada	80 to 1,000	Drillship	2006/2007	Not drilled yet*	>14 years
Sigguk/Eqqua, Disko West, Greenland	300 to 500	Semi-submersible + Drillship	2007	2010†	3 years
Area 193, Chukchi Sea, Alaska	40 to 50	Drillship	2008	Not drilled yet‡	>7 years
Prinovozemelsky, Kara Sea, Russia	80	Semi-submersible	2010	2014	4 years

* Drilling application submitted is contingent upon same season relief well equivalency. The operator has indicated to the National Energy Board that drilling could commence in 2020 if permits are granted by 2016.

† Cairn Energy drilled three of four planned exploration wells in Sigguk Block in 2010; only one encountered oil shows (not commercial).

‡ Shell commenced drilling in 2013, but operations were suspended before entering possible hydrocarbon-bearing zone, and has submitted a revised exploration plan to continue drilling in 2015.

Table 2-1. *Historical Exploration Phase Timelines*

Slope of Alaska before the Prudhoe Bay discovery. In the Chukchi Sea Outer Continental Shelf (OCS), there were five exploration wells drilled on five large prospects between 1989 and 1991, but a commercial discovery was not made.

Phase 2: Oil and Gas Appraisal—Initial Discovery to Project Investment Decision

Following a discovery, the activity shifts from exploration to appraisal drilling to evaluate the size and quality of the discovered resource. The number of appraisal wells needed to delineate the hydrocarbon accumulation and reduce uncertainty will depend on many factors, but it is reasonable to expect that the number will increase as the overall size or spatial extent of the prospect area increases. For example, a new anchor field of greater than 1 billion barrels of oil equivalent (BBOE) size covering areas of tens of thousands of acres on the Alaska OCS would likely require a minimum of three to four appraisal wells and, depending on reservoir compartmentalization or other complexities, may require as many as six to nine appraisal wells, as shown in Table 2-2.

As reservoir data become available, engineering studies are conducted to define alternative development concepts, and supporting data are gathered to assist with screening for commercial viability. Stakeholder engagement continues as onsite data collection and pre-FEED (front-end engineering and design) work are initiated to assess the best design to develop the resource and protect the environment.

Figure 2-6 outlines a range of timelines for the appraisal phase for a typical Alaska OCS opportunity. Furthermore, the projects in Table 2-2 demonstrate that a significant amount of time is needed to explore and appraise prospects in the Arctic and that the range of uncertainty on the overall Phase 1 and 2 timeline is very broad. Many developments are delayed in this phase due to commercial challenges, addressing stakeholder concerns, or litigation.

These high-level timelines outline a reasonable range of possible appraisal periods from 7 to 13 years,

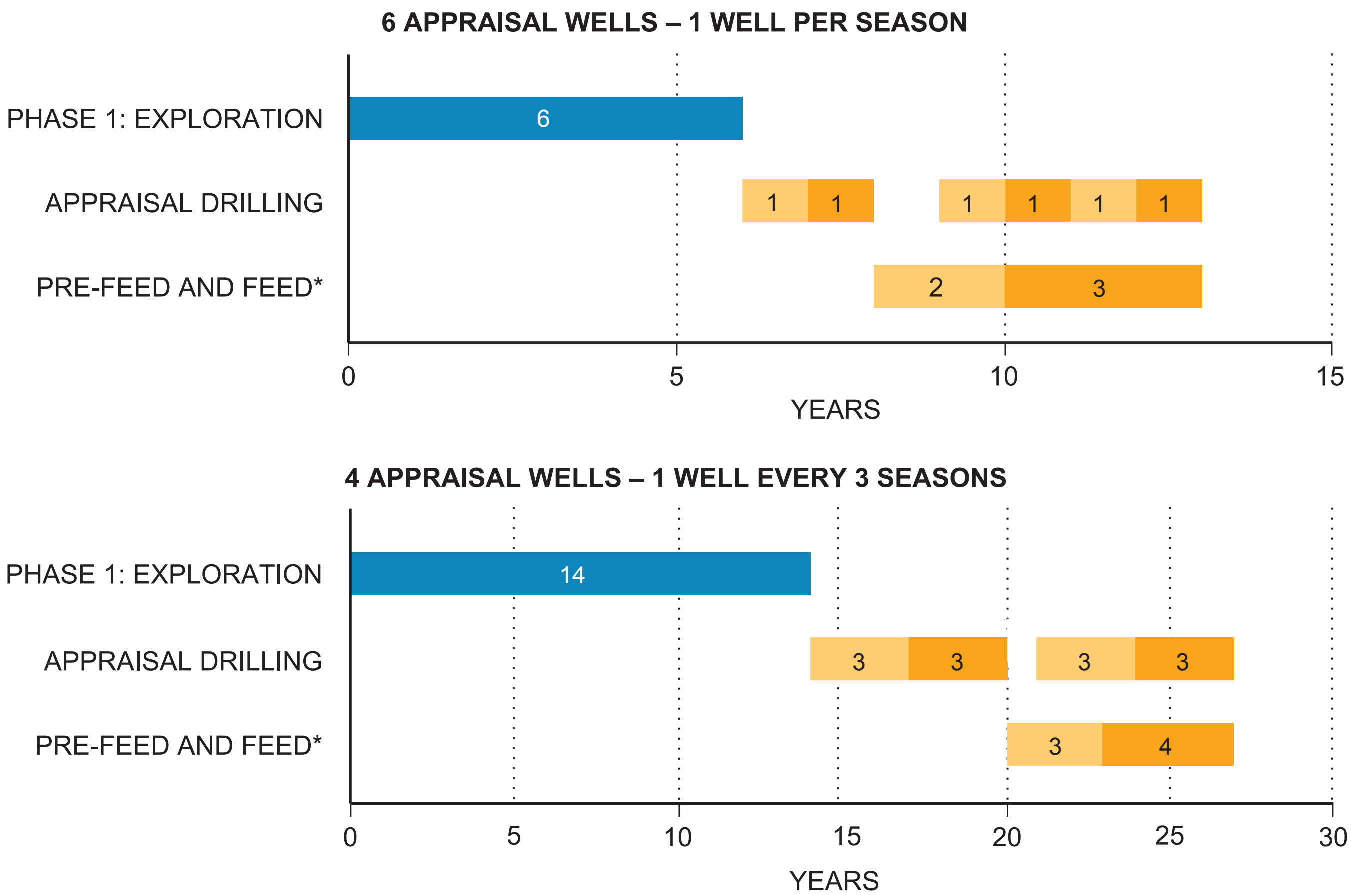
Appraisal Examples	Year Discovered	EUR* at Time of Discovery (MMBOE)	Number of Exploration/ Appraisal Wells	Year of Project Investment Decision	Years from Discovery to Investment Decision
Northstar, Beaufort OCS, Alaska	1983	200	1/5	1999	16
Odoptu, Sakhalin-1, Russia	1977	550	1/15	2003	26†
Amauligak, Beaufort Sea, Canada	1983	600	1/10	n/a	>30
Hibernia, Grand Banks, Canada	1979	1,100	1/8	1990	29
Hebron, Grand Banks, Canada	1980	850	3/3	2012	22
Point Thomson, Alaska North Slope	1977	1,200	1/6	2012	35‡

* Approximate values shown to illustrate the number of appraisal wells are related, along with many other factors, to the expected field size. EUR – estimated ultimate recovery; MMBOE – million barrels of oil equivalent.

† Ownership disputes delayed project until production sharing agreement was signed in 1995.

‡ Litigation issues were settled in 2012, and initial production system for condensate is sanctioned. However, the full field development plan has not been finalized.

Table 2-2. *Select Historical Appraisal Phase Timelines*



*FEED – front-end engineering design
Note: Numbers in chart are assumed duration for that activity; exploration phase shown in dark blue to show cumulative time.

Figure 2-6. *Phase 2: Typical Alaska OCS Appraisal Timeline Scenarios* and this only considers two of the main appraisal activities. It does not account for the time required to conduct shallow hazard surveys or obtain all the approvals, permits, and authorizations that are required for development. Even so, the combined Phase 1 and Phase 2 timelines for both scenarios could total between 13 and 27 years, exceeding the current 10-year primary lease term.

Phase 3: Oil Development—Project Investment Decision to First Oil

A project investment decision is achieved when operators have an approved work plan with funding in place as well as external support with stakeholder alignment, all regulatory approvals, marketing agreements, and primary contractors in place.

As shown in Table 2-3, the timeline from project investment decision to first oil (date when oil is first produced) is generally as quickly as is prudent, given stakeholder concerns have been addressed and support secured, and operators are committed to bringing production online.

To minimize the work done onsite in the remote and harsh climate of the Arctic, modular fabrication of production facilities generally takes place offsite in dry docks and fabrication yards. Depending on the complexity, detailed design and fabrication of an offshore drilling and production platform can take 3 to 5 years. Towing it to location and installation can take another year. Construction of a transportation system (pipeline and/or trans-shipment terminal and tankers) can proceed in parallel with the production platform construction. Development drilling from the platform follows installation, with commissioning and first oil usually within a year or two, once sufficient wells are drilled to start up the production and transportation system.

By layering the typical range of time taken for development activities on top of the range of exploration and appraisal timelines, it is clear that a significant amount of time is required—20 to 35 years to explore, appraise, and develop a new oil field in the Alaska OCS, as shown in Figure 2-7.

Gas Development

While the above discussion is focused on oil developments, it is important to note that gas developments often face many of the same challenges. Additionally, given gas market dynamics, it may take additional time to commercialize a gas resource.

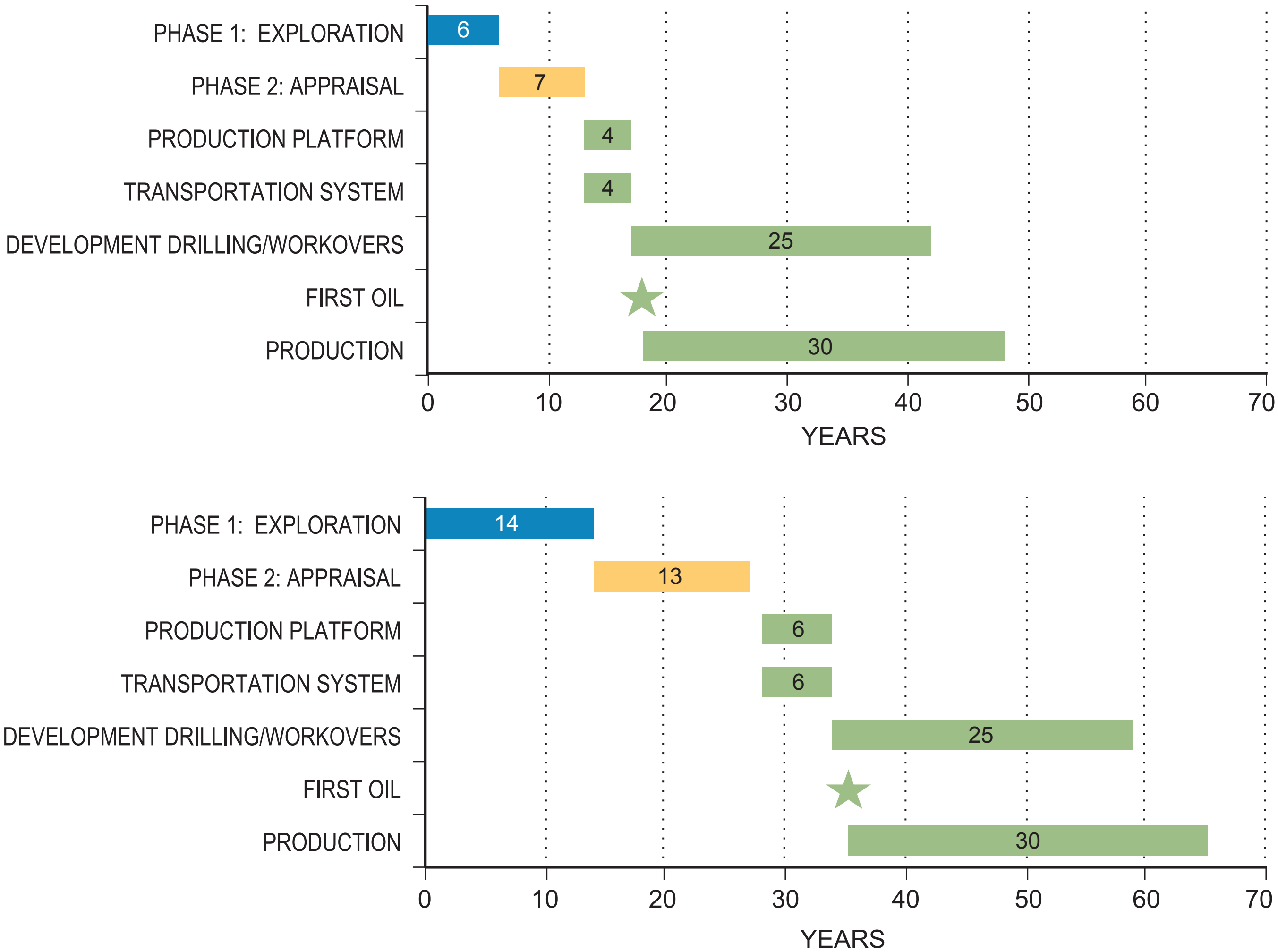
The state of Alaska and the North Slope producers have a 40-year history of evaluating options to market gas to Canada and the U.S. Lower 48 and international markets. However, given the high costs associated with Arctic development and the need for a gas pipeline, Alaska gas has not been competitive given that both Western Canada and the Lower 48 now have surplus gas and are looking to export LNG (liquefied natural gas). Until there is an economic way to bring gas to market, there is limited incentive for further natural gas exploration. The Alaska LNG project is the current project being advanced by the North Slope producers and the state of Alaska. A description of this project can be found in Chapter 1.

There remains uncertainty around the time required to obtain stakeholder alignment and all the permits and approvals needed to bring the Alaska LNG project to a final investment decision. The anchor fields of Prudhoe Bay and Point Thomson are forecast to sustain a plateau rate of 20 million tonnes

Oil Development Examples	Year of Project Investment Decision	First Oil Date	Years from Investment Decision to First Oil
Prudhoe Bay-Anchor field, Alaska North Slope	1974	1977	3
Northstar, Beaufort OCS, Alaska	1999	2001	2
Odoptu, Sakhalin-1, Russia	2003	2006	3
Hebron, Grand Banks, Canada	2012	2017*	5
Point Thomson, Alaska North Slope	2010	2016*	6

* Forecast first oil date.

Table 2-3. *Historical Development Phase Timelines*



Note: Numbers in chart are assumed duration for the activity; Phases 1 and 2 shown to highlight cumulative time.

Figure 2-7. *Phase 3: Alaska OCS Oil Development Scenarios*

per annum for 20 years. Follow-on gas development will be driven by proximity to the project's infrastructure and plateau timing unless the new field is large enough to justify additional facilities.

TYPICAL EXPLORATION AND DEVELOPMENT CONCEPTS

Exploration and development concepts can share many similarities, but a key difference is activity duration, with development requiring year-round operation. Exploration wells are drilled to test for the presence of hydrocarbons and to establish materiality including size, density, and quality of the resource. These wells could be converted into development wells but are typically plugged, made safe, and abandoned. Exploration drilling, by its short-lived nature, can therefore often be completed in the open water season or into ice and take advantage of concepts that might not be feasible for year-round operation.

Drilling Concepts for Exploration and Development

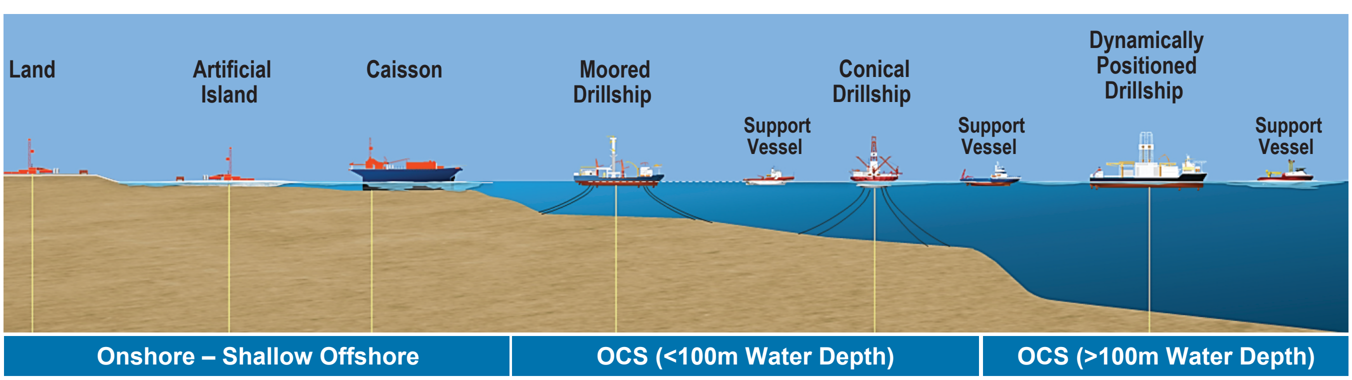
The water depth and ice regime determine the type of drilling system used for offshore exploration drilling in the Arctic. In shallow water, drilling has primarily been done from onshore, ice/gravel islands, or mobile bottom-founded structures such as the Steel Drilling Caisson with a conventional onshore rig. As the water depth increases, a moored floating drilling unit can be used, and, in deeper water, a dynamically positioned floating vessel would likely be used. Each drilling unit is supported by a marine complement that will manage ice, provide supplies, and respond in the unlikely event of an oil spill. Crew change is typically carried out by helicopter to shore. In general, the cost to operate a fully supported drilling system increases as the distance from onshore support bases, water depth, and severity of the ice regime increases.

A description of the various types of drilling systems appropriate for use in an Arctic setting follows, with many shown in Figure 2-8.

- **Land-Based Rigs:** Land-based rigs are used for onshore drilling or drilling offshore targets from land or landfast ice. These rigs can also be used on sand or gravel islands constructed to drill targets in relatively shallow water. The limit on these options is out to approximately 15 to 20 m of water depth for islands. This option also includes drilling extended-reach wells from onshore to offshore targets. This has been achieved to a 13 km measured depth at the Odoptu field off the coast of Sakhalin island.[2]
- **Jack-Up (not shown):** Existing jack-ups can be used in open water and in some ice environments. The legs of the present fleet of jack-ups are not designed for Arctic conditions and can only withstand limited ice impacts. Ice management would likely be required.
- **Bottom-Founded Structures:** These are structures that sit on the seabed. The Steel Drilling Caisson and previously the Concrete Island Drilling Structure are examples of bottom-founded structures and were purpose built for year-round Arctic exploration drilling in U.S. and Canadian waters but were limited for use in up to around 25 m water depth. Gravity-based structures are a subset of this type of structure and can be employed in up to approximately 100 m of water depending on local seabed conditions. An example of a gravity-based structure is the Hibernia production platform offshore Eastern Canada.
- **Drillships:** Ice-strengthened, moored drillships have been used in the open water season and during periods of ice in the U.S. and Canadian Beaufort and U.S. Chukchi Seas. They incorporate remote anchor release systems and must be supported by an ice management system including icebreakers and support vessels in conjunction with ice alert procedures if there is a plan to operate during an ice incursion while on location. Such vessels are suited for OCS areas up to approximately 100 m water depth.
- **Semi-Submersibles (not shown):** Existing semi-submersibles include harsh weather designs intended for Arctic open water operating environments. These may be able to be used in some ice prone situations with appropriate ice management.
- **Dynamically Positioned Drillship:** These drillships are generally used in open water environments. Deeper water ice prone areas will require a purpose-built drillship, such as the Stena IceMax, which incorporates special features to enable it to work in Arctic conditions. It would also need to be supported by an ice management system.

Production System Concepts for Development

The development concept is shaped by both the physical environment for operations and the field that is required to be developed. Once chosen, the selected development concept drives the timeline

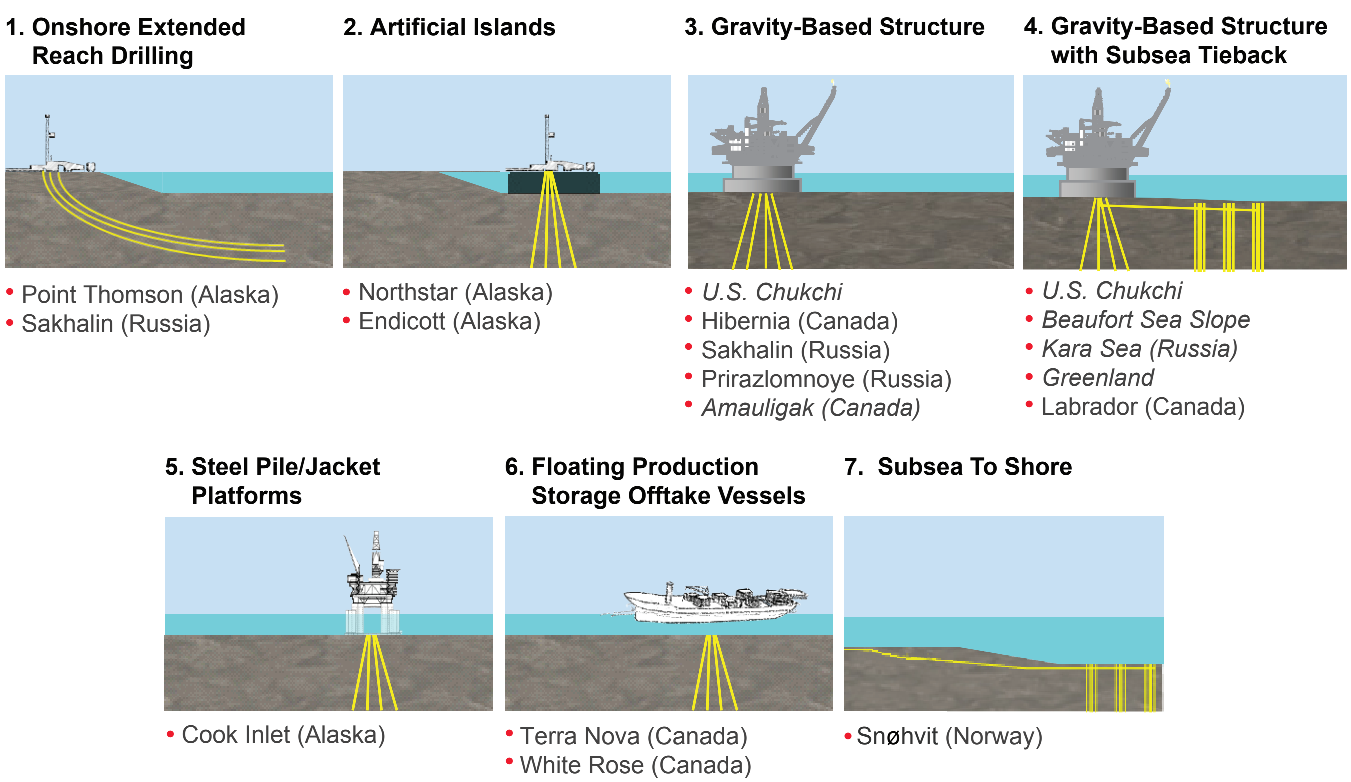


Source: Chevron.

Figure 2-8. *Arctic Drilling Concepts* for the investment and revenue profile that can be expected for the field. The development concept is primarily composed of the production platform and facilities, the drilling system, and the method of hydrocarbon transport. Moreover, these components are driven by water depth, field geometry, geology and size, and resource type and quality.

Globally, there are many different types of production systems that can be used in offshore oil and gas development and in particular in an Arctic setting. A production platform can have fluid processing equipment only or can also include drilling equipment. The production platform, topsides equipment, and transportation system can be considered the major components of an offshore development, and the costs are generally scalable as a function of water depth, production throughput, and storage volume. Drilling costs, however, can rise exponentially when moving from platform to MODU (mobile offshore drilling unit) drilled wells (up to 10 times higher dependent on length of open waters season, well depth, etc.). The main production systems suitable for Arctic offshore include the following and are shown in Figure 2-9.

- **Onshore Facilities:** This is where the production system is located onshore to produce offshore accumulations. Drilling can be completed offshore with a floating vessel and subsea production tied back to the onshore facilities, or extended-reach drilling can be used to drill offshore targets from onshore. The limit for this type of development is, in the case of extended-reach drilling, the drilling reach or, in the case of a subsea tieback, the distance fluids can be physically piped back to shore. An example of onshore processing of onshore drilled wells to produce an offshore resource is the Point Thomson development on the North Slope of Alaska.
- **Artificial Islands:** These are used offshore in water depths less than approximately 15 to 20 m and are usually constructed of sand or gravel. They have been used extensively in the North American Arctic for exploration and production. Examples of



Note: Italics distinguish areas with potential for a future development using this technology.
Source: Chevron and ExxonMobil.

Figure 2-9. *Typical Drilling and Production System Development Concept with Example Applications* artificial islands are the Northstar and Endicott developments off the coast of northern Alaska.

- **Gravity-Based Structures:** These are usually large concrete or steel structures designed to maintain position on the seafloor under the force of gravity. They can be used in up to approximately 100 m water depth (depending on local seafloor, soil, and ice conditions). Where the reservoir is spatially compact, subsea tiebacks are not usually required. However, as the extent of the reservoir increases, subsea tiebacks to these structures might be required. Examples of gravity-based structures include the Hibernia platform off the east coast of Canada, Prirazlomnaya in the Russian Pechora Sea, and the platforms offshore Sakhalin Island. All of these have been designed for Arctic or Arctic-like conditions including sea ice and in the case of Hibernia, iceberg contact.

- **Steel Pile/Jacket Platforms:** These are steel platforms that have piles driven into the seafloor to provide stability. They can be used in similar water depths to gravity-based structures and have some applicability in ice environments depending on the expected ice loads on the structure. Examples of steel pile/jacket platforms include the Cook Inlet platforms installed off the coast of Anchorage.

- **Floating (Production) Storage and Offtake (FPSO and FSO) Vessels:** These are large ship-shaped floating vessels that house the production facilities. They are anchored close to a subsea production system. Hydrocarbons flow from the reservoir up to the vessel through flexible pipes. FPSO vessels contain storage areas for subsequent tanker offloading, or pipelines are constructed to transport hydrocarbons from the vessels to shore. The Sakhalin-2 early production system is an example of an FSO vessel, and Phase 1 of the proposed Shtokman LNG project has considered a subsea development tied back to a floating FPSO vessel for processing.

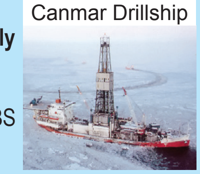
- **Subsea:** This involves a subsea production system where well fluids flow through seafloor manifolds and via pipelines to one of several locations (a platform, FPS[O] vessel, or to shore) for processing. Depending on water depth, the subsea wells would typically be drilled with a floating rig of some sort. The Snhøvit development in the Norwegian Barents Sea is an example of a subsea gas development tied back to shore for processing and conversion to LNG.

Globally, including the Alaskan Arctic OCS, where water depths are between approximately 15 m and 100 m and where sea ice is present, existing gravity-based structure technology can be used. Therefore, they are the most likely development concept one would expect to find deployed or proposed in this water depth range.

Implications of the Physical Environment on the Ability to Explore and Develop Globally

The ability to explore and later develop in the offshore is governed by ice conditions, water depth, and the length of the open water season. For exploration, water depth and ice conditions can determine the most appropriate drilling unit to use and combined with open water season information can dictate the support vessels required, the ease with which a drilling rig can be brought to location, and the number of wells that can be drilled in a season. Ice conditions and open water length can also determine the time required to acquire seismic and other geophysical data. For development, current gravity-based structures have a deployment depth limit, depending on soil and seafloor conditions, in the range of approximately 100 m. Development in deeper water than this would generally require use of subsea and/or floating solutions. Moreover, the length of the open water season also impacts the mobilization and installation period for development facilities and pipeline installation. These factors are well understood, and as discussed in Chapter 1, many exploration wells have safely been drilled and numerous developments have been carried out in Arctic ice prone areas. Figure 2-10 shows how the combination of these factors impacts the technical ability to explore and develop in various Arctic basins globally. Commercial considerations have not been overlaid, and Figure 2-10 is indicative of many situations but not intended to cover all possible situations. The U.S. Arctic resource potential is mostly in less than 100 m of water, has an open water season generally greater than 2 months, and encounters mainly first-year ice with the potential for multi-year ice. Therefore, the U.S. Arctic is generally able to be explored and developed using existing gravity-based structure technology as demonstrated in the U.S. and Russian Arctic.

Increasing Complexity to Explore & Develop

Physical Ice Environment and Water Depth		Technology to Explore & Develop
Description	**Examples**	
Typically ice free, any water depth • Minor first-year ice intrusions, icebergs possible	• South Barents Sea • Newfoundland	**Exploration & development proven** (Various drilling rigs, floating solutions, GBS, subsea tieback) Snøhvit Subsea  Hibernia GBS 
Any ice conditions, nearshore & shallow water • <~15m water	• Globally, near shore (including U.S. Beaufort and Chukchi Seas)	**Exploration & development proven** (Ice & gravel islands, concrete & steel structures, extended reach drilling from onshore) Spray Ice Island  Northstar 
Open water >~2 months, any water depth • Mainly first-year ice, potential for combination of multi-year ice, icebergs, and ice islands • Water depth determines development concept (greater or less than ~100m is key)	• Sea of Okhotsk • Pechora Sea • Labrador Sea • U.S. Chukchi & Beaufort Seas • South Kara Sea	**Exploration proven; development proven mainly in <~100m water** Ice management required <~100m development by GBS >~100m development by floating drilling & subsea tieback Canmar Drillship  Sakhalin-2 GBS 
Open water <~2 months, any water depth • Likely to encounter multi-year ice and/or icebergs, and in some locations ice islands • Water depth determines development concept (greater or less than ~100m is key)	• Deepwater Beaufort Sea • Deepwater Northern Russian Arctic Seas	**Exploration & development possible with technology improvements** Increased ice management capability and possible new technology
Limited to no open water • Frequent multi-year ice with embedded icebergs, and ice islands	• Northeast Greenland • Deepwater Northern Russian Arctic Seas	**Technology extensions or new technology required** Floating, robust ice managed solutions GBS/Subsea technology extensions or new technologies Difficult to mobilize equipment without open water season

Photos: Snøhvit Subsea - Statoil (Even Edland); Hibernia GBS - ExxonMobil; Spray Ice Island - BP – Amoco; Northstar - BP p.l.c.; Canmar Drillship - R. Pilkington; Sakhalin-2 GBS - Sakhalin Energy.

Figure 2-10. *Not One Arctic Physical Environment – Implications for Exploration and Development*

Hydrocarbon Transportation Options for Development

Access to markets is a key element to enable development, and transportation systems are key to delivering hydrocarbons to market. Depending on field location and size, different modes of transportation may be required and some may be more suitable than others. This section outlines pipeline and railcars as possible onshore options and pipelines and tankers as possible offshore options. All forms of transportation will potentially play a role in the energy future of the Arctic.

All options have different operating environments and must be designed to contain the fluid and ensure maintenance and monitoring to ensure ongoing integrity. Safety, reliability, cost, and stakeholder acceptance must be balanced when selecting a transportation option to ensure an acceptable solution is found.

Onshore Pipelines

Pipelines are a common method used globally to export oil and gas from the field to processing facilities and markets. Once a decision to use a pipeline has been made, routes are selected considering terrain and soil stability and other geographic characteristics and also considering cultural and environmentally sensitive areas. Once design is finalized, the required materials can be manufactured to specified standards and inspected and tested to assure quality control before shipping to the job site.

In remote areas such as the U.S. Arctic, the construction cycle starts with the building of infrastructure needed to support the actual pipeline construction. This can be a substantial construction project in itself, often requiring access roads, airstrips, staging areas, utilities, and housing for construction workers. By contrast, a pipeline project in the U.S. Lower 48 rarely incurs many of these costs, as local infrastructure and a skilled nearby workforce is typically available.

The pipeline installation will depend on a number of factors, but soil conditions are a primary consideration. In thaw stable soils,[b] the direct burial of pipe is usually the most cost effective solution and provides the best protection for the line while also limiting the environmental impact to a reversible and relatively short-term construction time frame. In contrast, in thaw unstable soils,[c] where heat from the product in the line could cause melting and line subsidence, pipelines, particularly for oil, are often installed above ground. For an above-ground oil line, passive refrigeration on the pipe supports is often required, as is the case with TAPS. These measures to protect the permafrost also protect the pipeline from undue stress; however, they also significantly increase the cost of an Arctic pipeline relative to a conventional underground line.

After fully inspecting and testing to ensure fluid containment, the pipeline is placed into service. Once operating, the fluid flow and pipeline are continuously monitored to ensure the system remains within design parameters. Additionally, methods to detect potential problems that might threaten the integrity of line are used, ranging from routine visual inspections to state-of-the-art inline methods using advanced sensing technologies, often referred to as "smart pigs."

At the end of its useful life, in the United States, the abandonment of a pipeline is subject to a regulated process. For conventional onshore pipelines this may involve emptying and cleaning the line, filling it with an inert noncorrosive substance such as nitrogen and sealing it to prevent interaction with the environment. Sometimes the pipe is removed.

b Thaw stable soil is permafrost in bedrock or well-drained, coarse-grained sediments, such as sand and gravel mixtures, where thawing due to heat from a buried pipeline will result in minor soil movement with the foundation remaining essentially sound.

c Thaw unstable soil is permafrost in poorly drained, fine-grained soils, especially silts and clays, where heat from a buried pipeline will cause thawing resulting in loss of strength and excessive settlement. In some cases, the soil can contain so much moisture that it flows.

The Trans-Alaska Pipeline System

The most important onshore pipeline in Alaska is TAPS, shown in Figure 2-11, a 48-inch diameter oil pipeline traversing an 800-mile route through three mountain ranges and across numerous rivers and streams from the Prudhoe Bay field on the North Slope to an ice-free shipping terminal at Valdez. Although both oil and gas discoveries have been made in the North Slope, only oil production and export has been enabled by TAPS.

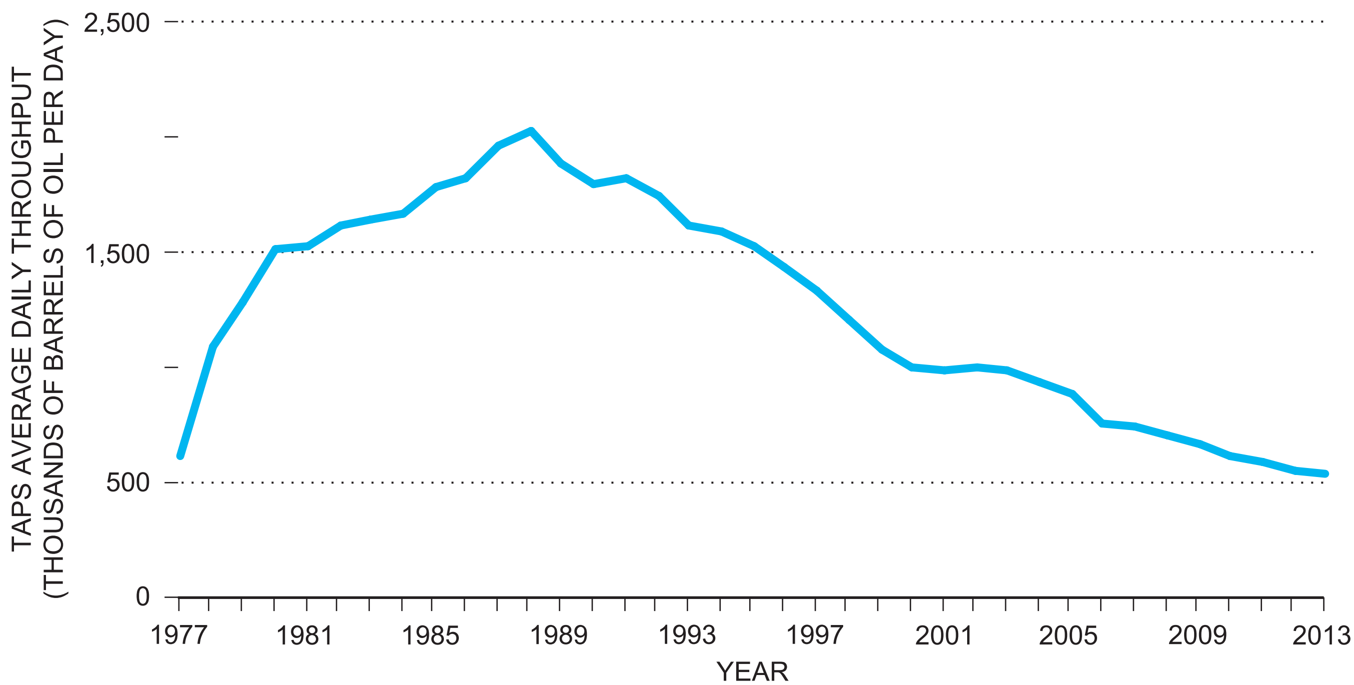
Constructed in the mid-1970s, this pipeline used the best technology available to protect the permafrost and provide migration corridors for wildlife while also maintaining operating temperatures and pressures that would ensure reliable oil transport.

The useful life of TAPS can be defined as a combination of the physical life and economic life of the system. The physical life can be extended as long as the integrity of the pipeline and facilities is maintained adequately to allow continued safe and environmentally sound oil transport. The economic life of TAPS, however, will be determined by how long it can attract oil producers and provide its owners with a reasonable economic return.

Since hitting a peak of more than 2 million barrels per day in the late 1980s, as shown in Figure 2-12, TAPS throughput has dropped and is currently around 500,000 barrels per day. Less oil means slower-moving oil and slower oil means colder oil. This slow-flowing cold oil results in challenging operating conditions.

Photo: ExxonMobil.

Figure 2-11. *Section of TAPS During Winter*



Source: Adapted from Alyeska Pipeline Service Company "Low Flow Impact Study" and website data, http://www.alyeska-pipe.com/TAPS/PipelineOperations/LowFlow.

Figure 2-12. *TAPS Throughput*

The best long-term solution for extending the useful life of TAPS is more oil. In the meantime, the pipeline's operator, Alyeska, has improved the line cleaning program with more frequent "pigging" and has redesigned pigs to ensure the line remains clear of deposited wax that precipitates from the oil as the temperature drops. It has also modified several pump stations to add heat and recirculate oil, mainly to prevent ice formation. Alyeska is continuing to research and implement adjustments necessary to operate TAPS safely and efficiently so that it can remain a viable component of the nation's energy infrastructure for as long as possible.

Onshore Gas Pipeline for Alaska LNG

The $45 to $65 billion Alaska LNG project is now in the pre-front-end engineering and design phase, which is expected to be completed in 2016. The proposed project facilities include: a liquefaction plant and terminal in the Nikiski area on the Kenai Peninsula; an 800-mile, 42-inch pipeline; up to eight compression stations; at least five takeoff points for in-state gas delivery; and a gas treatment plant located on the North Slope. The Alaska LNG project participants are the Alaska Gasline Development Corporation (an agency of the state of Alaska) and affiliates of TransCanada, BP, ConocoPhillips, and ExxonMobil. The Alaska LNG project has progressed further than any previous effort to monetize North Slope gas, but still has a number of commercial, technical, regulatory, and fiscal considerations that need to be addressed before a final investment decision is made.

Railcar

There has been limited use of railcars for hydrocarbon transportation in Alaska. The rail system is limited in scope to a single combined passenger/freight line connecting Seward-Whittier-Anchorage to Fairbanks and the Eielson Air Force Base. This railway is currently being used to import fuel products to interior Alaska. The rail line also transports coal from interior Alaska to Seward. This contrasts sharply with the Lower 48, where crude oil shipments by rail have increased substantially over the past few years. Even though the cost per distance traveled is more expensive by rail than by pipeline, the existing rail systems in the Lower 48 have been able to respond to changing energy supply dynamics more rapidly than pipeline infrastructure. Since Alaska currently relies on marine transportation to connect with the

Lower 48 and global markets, railway will potentially play only a limited logistics role in the development of oil and gas in the interior of the state, at least in the near to medium term.

Offshore Pipelines

The life cycle of an offshore Arctic pipeline is similar to onshore, but the design and installation methods also must consider strudel scour,[d] ice gouging,[e] thaw settlement of permafrost,[f] and upheaval buckling.[g] Considering these issues, offshore pipelines are generally buried. All of these issues have been addressed in existing pipeline designs in developments such as Northstar and Oooguruk. Therefore designs for future projects can address these four considerations.

In shallow water, conventional pipeline equipment can be used in the winter season to trench through the ice and bury the line. The BP Exploration's Northstar pipeline, shown in Figure 2-13, is an example of this shallow water construction technique.

In deeper waters where ice gouging is not an issue, the lines can be designed and installed on the seafloor as is done for deeper water non-Arctic offshore pipelines. Installation would take place in summer open water season. Longer pipelines may take multiple seasons to install, and the mobilization/demobilization or overwintering of equipment would significantly increase the cost of offshore Arctic pipelines compared to non-Arctic applications.

Additionally, the existing global fleet of vessels and barges for offshore pipeline construction are not designed for Arctic conditions. Therefore, for offshore Arctic pipelines, ice-strengthened and upgraded equipment and vessels would be required to operate in the Chukchi and Beaufort Seas.

Marine Terminals and Tankers

Transportation of oil via marine terminals and tankers is routine in non-Arctic waters and experience is growing in Arctic waters. The Valdez Marine Terminal at the end of TAPS, shown in Figure 2-14, is the most northerly ice-free port in the United States. The terminal was designed for oil loading to tankers and storage to allow North Slope production to continue even if marine transportation was interrupted. Tankers tie into a berth and oil spill containment booms are put in place before oil is transferred through the loading arms to the tanker. The first cargo of oil departed from Valdez on August 1, 1977, and more than 20,000 tankers have been loaded there.

d Strudel scour results from spring run-off water flowing onto the surface of a given sea ice expanse, which eventually drains away through cracks, seal breathing holes, etc. The resulting turbulence is strong enough to carve a depression into the seabed.

e Seabed gouging by ice is a process that occurs when floating ice features (typically icebergs and sea ice ridges) drift into shallower areas and their keel comes into contact with the seabed. As they keep drifting, they produce long, narrow furrows most often called gouges, or scours.

f Permafrost is a thick subsurface layer of soil that remains frozen throughout the year, occurring chiefly in polar regions.

g Upheaval buckling refers to the phenomenon that can occur when buried pipelines are subject to compression forces as a result of high temperature and pressure that can push the pipe through the soil cover.

Photo: INTECSEA.

Figure 2-13. *Construction of Northstar Offshore Pipeline*

Photo: Alyeska Pipeline Service Company.

Figure 2-14. *Valdez Marine Terminal*

At locations where the natural water depth is sufficient for berthing of large tankers and transport vessels, marine terminals can be built near shore. However, most of Alaska's coastal areas are in shallow water, where offshore terminals can potentially be more cost effective.[3]

The technical feasibility of marine terminals in Arctic areas has been established through successful experience in a wide range of port facilities. Seasonal loading of the double-hulled tanker MV *Arctic* occurred at Bent Horn, Cameron Island, Canada, from 1985 to 1996. Additionally, tanker loading has occurred for many years at terminals at Dekastri and Prigorodnoye off the coast of Sakhalin Island. More recently, Varandey Marine Terminal in the Barents Sea also operates in ice conditions and uses icebreakers for ice management at the terminal and for tanker escort.

Logistics and Infrastructure Considerations

Logistics and infrastructure are essential components for prudent development. Logistics encompass all of the measures and capabilities that are needed to manage the supply chain for an exploration or development project or an ongoing operation. The supply chain provides people, material and equipment, food, fuel, chemicals, spare parts, communications, etc., and also manages wastes.

Infrastructure generally means the fixed land-based facilities that support oil and gas activities. These include buildings of various types, roads, gravel islands, docks, causeways, airstrips, pipelines, power lines, wells, mines, and landfills. Both offshore and onshore oil and gas exploration, development, and production activities rely to some extent on land-based infrastructure.

From a global perspective, most offshore areas of the Arctic have sparse infrastructure and are logistically challenged due to their remoteness and the presence of ice during the majority of the year. There is a general lack of population centers, ports, and airfields to support offshore Arctic exploration and development activities. Existing fabrication yards for construction of offshore structures are thousands of miles from most offshore Arctic opportunity areas.

In terms of delivering material and equipment to a site via sea and for hydrocarbon export, there are two marine entry/exit routes through the Bering Strait and Barents Sea. The routes to access these marine entry points—through the Northwest Passage across Canada and the United States and the Northern Sea Route across Russia, as shown in the map in the Overview for Part One of this report—are challenged by heavy ice in the winter and variable ice conditions in the summer. Icebreaking vessels are an important component of Arctic infrastructure, and most of the world's modern, Arctic-capable icebreakers are concentrated in the Baltic countries and Russia. The existing overland export infrastructure that could be used to transport offshore Arctic oil and gas are limited to TAPS for oil across Alaska and a series of large gas pipelines leading south from Russia's Yamal Peninsula area. The communications infrastructure servicing the Arctic region is also challenged because most large communication satellites orbit the equator, which results in atmospheric interference for transmissions to and from Arctic locations.

In the U.S. Arctic, logistical and infrastructure requirements in the offshore vary widely depending on location (for additional information, see Chapter 7):

- **Areas with landfast ice:** Access to these areas is possible during the winter months via ice roads. These are roadways where floating ice is artificially thickened to support the intended loads. Construction of housing and power, and movement of heavy equipment, such as drilling rigs and drilling consumables, would be during winter months. Personnel transfer and resupply outside of this period would be done with rotary wing aircraft and crew boats capable of safe navigation in shallow water given the few ports in the area. Logistical and infrastructure requirements for this area can largely be met through an extension of the existing onshore capability and supply chain.
- **Areas beyond landfast ice:** These areas do not have road access, and all transport is via maritime vessels or aircraft. The continuous maritime operation drives the need for reliable transport over water. Exploration and development activities such as seismic, drilling, anchor handling and supply, and oil spill response are entirely dependent upon maritime vessels. These vessels are typically of size that they cannot access existing ports. Furthermore, air transport requirements place a significant burden on existing infrastructure.

Infrastructure to support offshore oil and gas development must undergo special considerations for the Arctic environment. Considerations for air operations include temperature, visibility and impact on subsistence hunting, while considerations for maritime vessels include technical capability and suitability for operations in ice to ensure safety and reliability of operations. Additionally, legal considerations must also be made to ensure vessels are compliant with the Jones Act, and environmental considerations to mitigate infrastructure impact on subsistence hunting and marine mammals. The current reality for the U.S. Arctic is that limited infrastructure is available to support offshore development, and additional ports, airfields, and roads will be necessary.

Ports, Airfields, and Roads

Deep draft ports are limited in Alaska. The Port of Dutch Harbor, 1,650 nautical miles from Seattle, WA, and 1,076 nautical miles from the Chukchi Sea, is the only deep draft, ice-free port from Unimak Pass west to Adak and north to the Bering Strait.

Air operations in the remote regions of Alaska are also limited and challenged due to weather conditions and the lack of suitably equipped airfields. Aviation is constrained by the general lack of logistics and operations support—fuel supplies, maintenance services, communications, etc. A further constraint is the lack of developed airspace that includes limited radar coverage to provide instrument flight rule (IFR) separation and limited communications and weather reporting. Limited number of suitably equipped airfields (hangars, Jet-A fuel, suitable aircraft rescue and fire fighting response, IFR ground-based approaches, runway lighting, ground de-ice capability, etc.) restrict not just location selection but also limit IFR range and payload. This is significant for offshore aviation due to the short range of helicopters, which require airfields/heliports to be as close as possible to the offshore operations. A further challenge for air support comes from the Federal Aviation Administration not yet establishing air traffic routing for offshore helicopter operations in the region, limiting the amount of air activity that can be done safely and efficiently.

The only main road that exists from Fairbanks to Prudhoe Bay (Deadhorse) is the James W. Dalton Highway. Access to and from Prudhoe Bay is also available by air. The flight time from Prudhoe Bay

(Deadhorse) or Barrow to Anchorage is more than 2 hours, requiring lead times to support any aviation movement of material or personnel.

Maritime Vessels

Maritime vessels needed for exploration (seismic survey ships, drilling rigs, anchor handlers, icebreakers, etc.) exist today, but with limitations. These limitations include a very small population of globally resourced vessels having requisite ice class and an even smaller subset that also satisfies the requirements under the Jones Act as discussed in Chapter 4. Compliance with the Jones Act results in ships being three times more costly to build and operate than vessels used by foreign-flag ocean carriers. Alternatives to maritime vessels, such as airships and hovercrafts, exist today but remain undemonstrated and not without issues to be addressed. For example, airship operability and reliability still need to be proven in Arctic conditions. If qualified, however, these vessels may be suitable for resupply.

In addition, ships operating in the Arctic will be exposed to ice and need to be specially designed and strengthened for the requisite operating conditions. Rules for ship design in ice have been in existence for more than 100 years and have undergone continuous improvement. This process is driven by a combination of experience, incidents, and improved calculation methods. Further evolution of ship design and classification society rules (e.g., DNV GL, ABS, Lloyds) continue to take place and form the basis of the rules in force today. The Polar Code, adopted by the International Maritime Organization's Marine Safety Committee in November 2014, consolidates and provides common baselines of requirements for polar shipping.

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3 IMV Projects Atlantic Inc., *Arctic Offshore Technology Assessment of Exploration and Production Options for Cold Regions of the U.S. Outer Continental Shelf*, prepared for U.S. Department of the Interior, Minerals Management Service, IMVPA Project No. C-0506-15, January 2008.

Chapter 3

Implementation of U.S. Strategy for the Arctic Region

SCOPE

This chapter highlights the long history of policy relevant to prudent development of the nation's Arctic resources. The National Strategy for the Arctic Region (NSAR), the Implementation Plan for the National Strategy for the Arctic Region (IPNSAR), and the Arctic Council are described, and the challenges associated with making, implementing, and coordinating Arctic policy at the local, state, national, and international levels are discussed.

INTRODUCTION

Since the end of the Cold War, the Arctic has been a region where economic development, environmental stewardship, and international cooperation coexist amidst changes in political as well as climatic conditions. In recent years, greater international attention has focused on a changing Arctic environment and new economic opportunities that are facilitated by technological advancements. The engagement of the international oil and gas industry in the Arctic, as discussed in this report, is an example of this coexistence.

Continued development of Arctic energy resources is not yet guaranteed and will require nations, industry, and other stakeholders to balance the benefits of resource development and environmental stewardship. While both the U.S. government and other Arctic nations acknowledge the importance of sustainable and responsible resource development in the Arctic (or, in the language of this report, prudent development), some nations place greater emphasis on development and others on stewardship. As a result, there is an unevenness of approach related to resource development in the circumpolar Arctic. For the United States, development of its offshore energy resources has been slow to proceed given the perceived fragility of the Arctic ecosystem and lingering policy questions following the Macondo incident in the Gulf of Mexico. Therefore, to facilitate prudent resource development in the U.S. Arctic, confidence must be cultivated among all stakeholders, including, but not limited to, the U.S. and foreign governments, local communities, industry, and the environmental community. Additionally, organization and prioritization of internal federal agency activities are paramount as the United States approaches its chairmanship of the Arctic Council in April 2015.

U.S. NATIONAL STRATEGY FOR THE ARCTIC REGION

U.S. Strategy for the Arctic Region over Time: A History of Bipartisan Support

The U.S. strategy for the Arctic has evolved from President Richard Nixon's National Security Decision Memorandum (NSDM-144) in 1971. Since then, Presidents Ronald Reagan, Bill Clinton, George W. Bush, and Barack Obama have all issued national strategy documents pertaining to U.S. interests in the Arctic. Notably, one of the primary challenges for U.S. policymakers in implementing a national strategy toward the Arctic is, and has been since 1971, the challenge of coordinating federal activities across a multitude of federal agencies with responsibilities and interests in the region. Table 3-1 provides a snapshot of presidential documents that have guided U.S. Arctic policy over the past four decades.

The four decades of national policy outlined in Table 3-1 serve as a reminder that the Arctic is not a new frontier for U.S. national interests. Traditionally, these policies have included national security, environmental protection, economic development, and science.[1] However, changes in the Arctic climate have raised the profile of the Arctic and increased the focus on international cooperation, economic development, and environmental stewardship. Increased ability to access the Arctic as a result of declining sea ice cover, coupled with a growing need for new resources and changing geopolitical factors, have driven U.S. and other countries' interest in the Arctic.

Today, President Obama's NSAR, which builds on the 2009 NSPD-66/HSPD-25, is the primary driver of U.S. Arctic policy. The NSAR is described in the following section. In line with this overarching 2013 national strategy, numerous federal agencies have developed their own Arctic strategy documents to clarify their roles and responsibilities within the national Arctic strategy. Table 3-2 provides a catalog of the most recent documents. As a general rule, the agencies that have been the most proactive with regards to developing strategies toward the Arctic have been the Departments of Homeland Security (via the U.S. Coast Guard), Interior, Commerce (via the National Oceanic and Atmospheric Administration), and Defense (and Department of the Navy), and the National Science Foundation and NASA. The U.S. Coast Guard is one of the lead U.S. agencies in the Arctic, with its long history of operating in U.S. waters in the Arctic and its role in maritime safety, security, and stewardship. While this chapter will not explore these department- and agency-level activities in great depth, it is important to note the breadth of federal government interest in and activity on Arctic issues—a significant issue for the coordination and implementation of Arctic policies.

Document Title	Issuer/Year	Primary Objectives
National Security Decision Memorandum (NSDM-144)	Nixon/1971	• To establish an Interagency Arctic Policy Group
National Security Decision Directive (NSDD-90)	Reagan/1983	• Protect essential security interests in the Arctic region • Support sound and rational development in the Arctic region; minimize adverse effects on environment • Promote scientific research contributing to knowledge of the Arctic environment • Promote mutually beneficial international cooperation in the Arctic to achieve the above
Presidential Decision Directive (PDD/NSC-26)	Clinton/1994	• Meet post-Cold War national security and defense needs • Protect the Arctic environment and conserve its biological resources • Assure that the natural resource management and economic development in the region are environmentally sustainable • Strengthen institutions for cooperation among the eight Arctic nations • Involve the Arctic's indigenous peoples in decisions that affect them • Enhance scientific monitoring and research into local, regional, and global environment issues
National Security Presidential Directive 66/Homeland Security Presidential Directive 25 (NSPD-66/HSPD-25)	George W. Bush/2009	• Meet national security and homeland security needs relevant to the Arctic • Protect the Arctic environment and conserve its biological resources • Ensure that natural resource management and economic development in the region are environmentally sustainable • Strengthen institutions for cooperation among the eight Arctic nations • Involve the Arctic's indigenous communities in decisions that affect them • Enhance scientific monitoring and research into local, regional, and global issues
National Strategy for the Arctic Region (NSAR)	Obama/2013	• Advance U.S. security interests • Pursue responsible Arctic region stewardship • Strengthen international cooperation

Table 3-1. *National Strategy Documents for the Arctic Region*

Document Title	Agency/Year	Primary Objectives
Arctic Roadmap	United States Navy/2014 and 2009	• Developing strong cooperative partnerships with interagency and international Arctic stakeholders • Actively and competently contributing to safety, security, and stability • Acquiring the right capability at the right cost and right time to meet combatant commander requirements • To be perceived as an active contributor to a safe, secure, and stable region • Understanding when significant access for shipping and other maritime activity is likely to develop
Final Recommendations of the Interagency Ocean Policy Task Force	The White House Council on Environmental Quality/2010	• Ecosystem-based management • Coastal and marine spatial planning • Inform decisions and improve understanding • Coordinate and support • Resiliency and adaptation to climate change and ocean acidification • Regional ecosystem protection and restoration • Water quality and sustainable practices on land • Changing conditions in the Arctic • Ocean, coastal, and great lakes observations, mapping, and infrastructure
Report to Congress on Arctic Operations and the Northwest Passage	Department of Defense/2011	• Prevent and deter conflict in the Arctic • Prepare to respond to a wide range of challenges and contingencies
Arctic Strategy	United States Coast Guard (Department of Homeland Security)/2013	• Improving awareness • Modernizing governance • Broadening partnerships
Arctic Strategy	Department of Defense/2013	• Maintain a secure and stable region where U.S. national interests are safeguarded, the U.S. homeland is protected, and nations work cooperatively to address challenges
NOAA's Arctic Action Plan: Supporting the National Strategy for the Arctic Region	National Oceanic and Atmospheric Administration/2014	• Advance U.S. security interests • Pursue responsible Arctic region stewardship • Strengthen international cooperation

Table 3-2. *Agency-Level Strategy Documents for the Arctic Region since 2009*

Current National Strategy for the Arctic Region

In May 2013, President Obama released the NSAR, as shown in Table 3-3. The primary goal of the NSAR is to define U.S. national interests in the Arctic and to "position the United States to respond effectively to challenges and emerging opportunities arising from significant increases in Arctic activity due to the diminishment of sea ice and the emergence of a new Arctic environment," and to define the primary strategies for pursuing those interests. The NSAR explicitly states that it seeks to build upon and clarify the existing Arctic region policy outlined in President Bush's NSPD-66/HSPD-25 and is not intended to supplant that existing policy guidance.

The NSAR outlines the goals, as shown in the text box on the primary goals of NSAR, that the Obama administration seeks in the Arctic, stating that "[W]e seek an Arctic region that is stable and free of conflict, where nations act responsibly in a spirit of trust and cooperation, and where economic and energy resources are developed in a sustainable manner that respects the fragile environment and the interests and cultures of indigenous peoples."[2] There are three lines of effort identified as the foundation for the NSAR: (1) the advancement of U.S. security interests, (2) the pursuit of responsible stewardship for the Arctic region, and (3) the strengthening of international cooperation.[3] The guiding principles identified by the NSAR to inform the U.S. approach to the three lines of effort are: safeguard peace and stability, make decisions using the best available information, pursue innovative arrangements, and consult and coordinate with Alaska natives.[4]

The NSAR provides strategic guidance on U.S. policy priorities in the Arctic, without providing specific direction or tasks for federal agencies as to what specific activities they should be undertaking or how they should seek to implement the strategy. These specific tasks are promulgated in the Implementation Plan for the National Strategy for the Arctic Region, released in January 2014. The IPNSAR is constructed around the three primary lines of effort and encompass existing and future projects and activities undertaken by the U.S. government, with a minimum of one initiative being identified for each of the goals in the outlined in the text box. A fuller discussion of the IPNSAR initiatives that are relevant to this study can be found in the sections that follow. For a full list of the initiatives and lead agencies in the IPNSAR, see Table 3-3.

Primary Goals of the Obama Administration's National Strategy for the Arctic Region

1. Advance United States Security Interests
   a. Evolve Arctic Infrastructure and Strategic Capabilities
   b. Enhance Arctic Domain Awareness
   c. Preserve Arctic Region Freedom of the Seas
   d. Provide for Future United States Energy Security
2. Pursue Responsible Arctic Region Stewardship
   a. Protect the Arctic Environment and Conserve Arctic Natural Resources
   b. Use Integrated Arctic Management to Balance Economic Development, Environmental Protection, and Cultural Values
   c. Increase Understanding of the Arctic through Scientific Research and Traditional Knowledge
   d. Chart the Arctic Region
3. Strengthen International Cooperation
   a. Pursue Arrangements that Promote Shared Arctic State Prosperity, Protect the Arctic Environment, and Enhance Security
   b. Work through the Arctic Council to Advance U.S. Interests in the Arctic Region
   c. Accede to the Law of the Sea Convention
   d. Cooperate with Other Interested Parties

The Role of Oil and Gas Development in the NSAR

The NSAR notes the importance of the Arctic in ensuring U.S. energy security in the future. In doing so, the NSAR acknowledges the vast resource potential of the Arctic and the "fresh ideas for commercial initiatives and infrastructure development in the region"[5] that those resources have inspired, all while reiterating the U.S. dedication to environmental responsibility and protection. Of particular relevance to this study is the NSAR's focus on energy security, integrated Arctic management, Arctic infrastructure, scientific research, and traditional knowledge—all of which will impact the development of energy resources in the Arctic.

Prudent development of Arctic resources can further U.S. interests in ensuring national energy security and promoting regional development, which is important both for indigenous peoples and regional economies as well as the U.S. economy as a whole. Resource development in the Arctic will spur investment in infrastructure, research and development, better scientific understanding of unique and changing ecosystems, and more responsive safety and search and rescue capabilities. As is discussed throughout this report, the energy industry is already undertaking significant research and development to address those issues, and many of the initiatives both complement and support U.S. objectives and goals.

The Implementation Plan for the National Strategy for the Arctic Region

The IPNSAR, released by the White House in January 2014, "sets forth the methodology, process, and approach for executing the Strategy."[6] The IPNSAR is intended to complement and build upon initiatives and activities already being undertaken by federal, state, local, and tribal authorities, as well as by private industry and international partners. The IPNSAR

#	IPNSAR Initiative Title	Lead Federal Agency	Initiatives Relevant to This Study
Advance United States Security Interests: Evolve Arctic Infrastructure and Strategic Capabilities			
1	Prepare for Increased Activity in the Maritime Domain	Department of Transportation	Chapter 7
2	Sustain and Support Evolving Aviation Requirements	Department of Transportation (FAA)	Chapter 7
3	Develop Communication Infrastructure in the Arctic	Department of Commerce (NTIA)	Chapters 7, 9, & 10
4	Enhance Arctic Domain Awareness	U.S. Coast Guard	Chapters 5 & 9
Advance United States Security Interests: Preserve Arctic Region Freedom of the Seas			
5	Sustain Federal Capability to Conduct Maritime Operations in Ice-Impacted Waters	Department of Homeland Security	Chapters 5, 7, 9, & 10
6	Promote International Law and Freedom of the Seas	Department of State	Chapter 7
Advance United States Security Interests: Provide for Future United States Energy Security			
7	Pursue the Development of Renewable Energy Resources*	Department of Energy	
8	Ensure the Safe and Responsible Development of Nonrenewable Energy Resources*	Department of Interior	All Chapters
Pursue Responsible Arctic Region Stewardship: Protect the Arctic Environment and Conserve Natural Resources			
9	Conserve Arctic Ecosystems	National Oceanic and Atmospheric Administration	Chapters 9 & 10
10	Improve Hazardous Material Spill Prevention, Containment, and Response*	U.S. Coast Guard (offshore) or Environmental Protection Agency (onshore)	Chapters 8, 9, & 10
Pursue Responsible Arctic Region Stewardship: Use Integrated Arctic Management to Balance Economic Development, Environmental Protection, and Cultural Values			
11	Use Integrated Arctic Management to Balance Economic Development, Environmental Protection, and Cultural Values	Department of Interior and Office of Science and Technology Policy	All Chapters
Pursue Responsible Arctic Region Stewardship: Increase Understanding of the Arctic through Scientific Research and Traditional Knowledge			
12	Develop a Network of Observations and Modeling to Support Forecasting and Prediction of Sea Ice*	Department of Defense	Chapters 5 & 10
13	Implement the Pilot Distributed Biological Observatory in the Pacific Arctic	National Oceanic and Atmospheric Administration	Chapters 9 & 10
14	Develop Integrated Ecosystem Research in the Beaufort and Chukchi Seas	National Science Foundation	Chapters 9 & 10
15	Improve Understanding of Glacial Dynamics*	National Science Foundation	
16	Understand Terrestrial Ecosystem Processes	Department of Interior	Chapters 9 & 10
17	Investigate Wildland Fires in the Arctic*	Department of Interior	
18	Understand Atmospheric Processes to Improve Climate Predictions*	Department of Energy	Chapter 5
19	Support a Circumpolar Arctic Observing System*	National Science Foundation	Chapter 9
20	Integrate Arctic Regional Models*	Department of Energy	
21	Improve Arctic Community Sustainability, Well-being, and Cultural and Linguistic Heritage	Smithsonian Institute	Chapter 10
22	Understand Human Health in the Arctic	Department of Health and Human Services	Chapter 10
Pursue Responsible Arctic Region Stewardship: Chart the Arctic Region			
23	Chart the Arctic Region	National Oceanic and Atmospheric Administration	Chapter 7
Strengthen International Cooperation: Pursue Arrangements that Promote Shared Arctic State Prosperity, Protect the Arctic Environment, and Enhance Security			
24	Promote Arctic Oil Pollution Preparedness, Prevention and Response Internationally*	U.S. Coast Guard	Chapters 4 & 8
25	Enhance Arctic Search and Rescue	U.S. Coast Guard	Chapters 6 & 7
26	Prevent Unregulated Arctic High Seas Fisheries	Department of State	
27	Reduce Transport of Contaminants	Environmental Protection Agency	Chapter 10
28	Identify and Assess Invasive Species Risks and Impacts	Department of Interior	Chapter 9
29	Promote Scientific Research and Monitoring*	National Science Foundation	Chapters 5 to 10
Strengthen International Cooperation: Work through the Arctic Council to Advance U.S. Interests in the Arctic Region			
30	Develop a Robust Agenda for the U.S. Chairmanship of the Arctic Council*	Department of State	Chapter 3
31	Reduce Black Carbon in the Arctic*	Environmental Protection Agency	Chapter 9
Strengthen International Cooperation: Accede to the Law of the Sea Convention and Related Affairs			
32	Accede to the Law of the Sea Convention	Department of State	
33	Delineate the Outer Limit of the U.S. Extended Continental Shelf	Department of State	
34	Resolve Beaufort Sea Maritime Boundary	Department of State	
Strengthen International Cooperation: Cooperate with Other Interested Parties			
35	Expedite International Maritime Organization Polar Code Development and Adoption	U.S. Coast Guard	Chapter 7
36	Promote Arctic Waterways Management	U.S. Coast Guard	Chapter 7
* Denotes initiatives with a Department of Energy role.			

Table 3-3. *Initiatives in the Implementation Plan for the National Strategy for the Arctic Region*

serves as a catalog of the initiatives and actions underway, providing information such as the objectives, next steps, metrics for measuring success, and a list of the federal agencies involved. The IPNSAR is organized according to the lines of effort that were laid out in the NSAR: advance United States security interests, pursue responsible Arctic region stewardship, and strengthen international cooperation. The IPNSAR also identifies a set of guiding principles that all agencies are to reflect as they carry out the implementation of the NSAR. While the IPNSAR is directed by the same guiding principles identified in the NSAR, the IPNSAR places special emphasis on the need to foster partnerships with Alaska natives and to coordinate and integrate activities across the federal government, recognizing these as important to all three NSAR lines of effort.

Successful Arctic prudent development can occur with existing scientific understanding, capabilities, and technologies given the breadth and depth of knowledge that exists about the Arctic as discussed in subsequent chapters of this report. As this foundation of knowledge is built upon through continued improvements in scientific understanding of the Arctic environment, society and ecology, emergency response capabilities and technologies, infrastructure and logistics, and through effective international cooperation, prudent development of the Arctic will continue to be enabled. The IPNSAR identifies multiple initiatives related to each of these areas. The IPNSAR identifies 36 different initiatives, as shown in Table 3-3, each of which falls into one of the three NSAR lines of effort, and identifies multiple next steps for each initiative. The Department of Energy is listed as the lead agency for three projects, none of them directly related to oil and gas production in the Arctic, and as a supporting agency for 10 initiatives, several of which do have direct applications related to energy development.

The Implementation Plan and This NPC Study

As seen in Table 3-3, there are numerous initiatives identified in the IPNSAR that cover a wide variety of policy priorities, research areas, and technology needs, many of which overlap explicitly with the findings of this report. The IPNSAR is particularly relevant to the Technology and Operations chapters of this report (Part Two), while later sections of this chapter and Chapter 4 discuss the Arctic Council directly. The initiatives relevant to this report are identified in Table 3-3 along with a reference to the chapter that they relate to. For more information on what this report has concluded with regards to those initiatives, refer directly to the chapters identified.

Enhancing Coordination of National Efforts in the Arctic

On January 21, 2015, President Obama issued an Executive Order on "Enhancing Coordination of National Efforts in the Arctic," which created an Arctic Executive Steering Committee to "provide guidance to executive departments and agencies (agencies) [sic] and enhance coordination of Federal Arctic policies across agencies and offices, and, where applicable, with State, local, and Alaska Native tribal governments and similar Alaska Native organizations, academic and research institutions, and the private and nonprofit sectors." The chair of the steering committee will be the head of the Office of Science and Technology Policy or designee. The vice chair of the steering committee will be the U.S. National Security Adviser or designee. The other members of the steering committee are listed in the text box.

As an important member of this newly established Executive Steering Committee and with the steering committee's mandate to enhance coordination with the private sector, the Department of Energy should take the leading role in promoting prudent development of offshore U.S. Arctic energy resources to ensure U.S. energy security and provide economic benefits to the people of the North. The role of the Department of Energy on the steering committee will be particularly important because no single point of contact exists within the federal government to coordinate industry's engagement in the U.S. Arctic to improve the potential for prudent development. The Department of Energy should designate a senior official within the department who will serve as a formal liaison between industry and the Department of Energy, which would enable industry to engage on issues related to the economic benefits of energy development, the status of Arctic-oriented research matters, and the sharing of best industry practices on oil spill preparedness, prevention, and response with the department, which in turn can share this information with members of the steering committee.

Arctic Executive Steering Committee Members

- Office of Science and Technology Policy
- Council on Environmental Quality
- The Domestic Policy Council
- National Security Council
- Department of State
- Department of Defense
- Department of Justice
- Department of the Interior
- Department of Agriculture
- Department of Commerce
- Department of Labor
- Department of Health and Human Services
- Department of Transportation
- Department of Energy
- Department of Homeland Security
- The Office of the Director of National Intelligence
- The Environmental Protection Agency
- The National Aeronautics and Space Administration
- The National Science Foundation
- The Arctic Research Commission
- The Office of Management and Budget
- The Assistant (or designee) to the President for Public Engagement and Intergovernmental Affairs
- Other agencies or offices as determined appropriate by the chair of the Steering Committee

THE ARCTIC COUNCIL

What It Is

Established in 1996 through the Ottawa Declaration, the Arctic Council traces its origins to the 1991 Finnish-led Arctic Environmental Protection Strategy initiative signed by the eight Arctic states (the United States, Canada, Russia, Norway, Denmark, Sweden, Finland, and Iceland). Built on a foundation of environmental stewardship and focusing its energies and activities on the Arctic environment and sustainable development, the Arctic Council has become the most prominent and visible multilateral Arctic institutional body. Although the Arctic Council continues its work on environmental and sustainable development issues nearly 20 years after its creation, the organization and its framework have evolved beyond their original purview.

Today, the Arctic Council consists of the eight Arctic states, twelve observer states (China, Korea, France, Germany, The Netherlands, Poland, Spain, the U.K., Italy, Japan, Singapore, and India), nine intergovernmental and interparliamentary organizations, eleven nongovernmental organizations, six permanent participant groups representing indigenous communities, six working groups, and four task forces. Representing approximately 500,000 Arctic indigenous inhabitants, the permanent participant groups have full consultation rights in connection with the Council's negotiations and decisions and play a unique and important role in the activities and decisions of the Council. The permanent participants are vested particularly in protecting their cultural heritage and their right to subsistence living, while also improving the health, well-being, and economic stability of indigenous communities. The primary role of observer states is to observe the work of the Arctic Council and make relevant contributions at the level of the working groups. While observer states do not have voting rights in the Council, they may propose projects through an Arctic nation or a permanent participant and may provide their views on issues under discussion in the Council's subsidiary bodies.

As one of the eight Arctic member states, the United States plays a significant role in the Arctic Council and has helped to shape the institution's goals and activities. During its first chairmanship of the Arctic Council from 1998 to 2000, the United States helped to finalize the framework for the Council's Sustainable Development Program, which affirmed the commitment of the Arctic states to sustainable development, including economic and social development, improved health conditions, and cultural well-being. During the U.S. chairmanship, the Arctic Council also adopted the Regional Programme of Action for the Protection of the Arctic Marine Environment from Land-based Activities (RPA). The RPA is designed to be a source of guidance in devising and implementing sustained action to prevent, reduce, control, and eliminate marine degradation from land-based activities. RPA also provides the framework for the working group titled Protection of the Arctic Marine Environment, which aims to prevent and control marine pollution and has supported Russia's efforts to improve environmental protection within its own Arctic region.

Role in the Implementation Plan for the National Strategy for the Arctic Region

The IPNSAR also contains a section devoted to international cooperation through the Arctic Council, subtitled "Work through the Arctic Council to Advance U.S. Interests in the Arctic Region."[7] This section, which includes two agenda items, recognizes the opportunities that participation in the Arctic Council offers the United States to advance its interests, most notably through its chairmanship of the Council, commencing in April 2015.

The first initiative explicitly related to the Arctic Council directs the Department of State, in collaboration with seven other federal agencies and advisory organizations, to "develop a robust agenda for the U.S. chairmanship of the Arctic Council."[8] (The other agencies listed include the Department of Commerce, the Department of Energy, the Department of Homeland Security [U.S. Coast Guard], the Department of the Interior, the Environmental Protection Agency, the National Science Foundation, and the U.S. Arctic Research Commission.) The IPNSAR also directs U.S. agencies, under the leadership of the Environmental Protection Agency, to continue ongoing work that strives to better understand and reduce black carbon emissions in the Arctic region. In preparation for the U.S. chairmanship of the Arctic Council, the IPNSAR specifies the following next steps:

- Hold listening sessions with targeted audiences, including partners such as the state of Alaska and Alaska natives
- Develop an overarching theme for the U.S. chairmanship
- Develop high-quality project proposals with useful, concrete deliverables
- Determine U.S. chairmanship priorities within the Arctic Council by the end of 2014
- Present U.S. priorities to other Arctic Council members and permanent participants and develop Arctic Council 2015 Ministerial Declaration by spring of 2015
- Assume Arctic Council chairmanship in June 2015
- Undertake projects and initiatives through Arctic Council working groups, expert groups, task forces, and other means between June 2015 and spring of 2017
- Hold Arctic Council Deputy Ministers' meeting in spring of 2016
- Consider Presidential Arctic Summit in connection with the 20th anniversary of the Arctic Council in spring of 2016
- Convene Arctic Council Ministerial meeting in May 2017.

The proposed U.S. chairmanship agenda was briefed to the Senior Arctic Officials of the Arctic Council on October 21-22, 2014. There were three overarching priorities: addressing the impacts of climate change in the Arctic (with particular emphasis on reducing black carbon and methane emissions), stewardship of the Arctic Ocean (contemplating designating marine protected areas), and improving economic and living conditions of the people of the North (with a focus on renewable energy and improved water and sanitation).

While the agenda for any given chairmanship of the Arctic Council is vital, the real work of the Arctic Council occurs in its six working groups, four task forces, and various assessments. Examples of particularly relevant Arctic Council assessments to prudent development have been the reports on recommended practices for Arctic oil spill prevention, the Arctic marine shipping assessment, and the agreement on cooperation on marine oil pollution, preparedness, and response.

The Arctic Council's Budget

The Arctic Council has no budget of its own to complete projects, relying on funding from its member states to support its work. The Arctic Council's member states share equally the burden of funding the Council's Permanent Secretariat based in Tromsø, Norway, but the budget is relatively small. Typically, an Arctic Council member state contributes funding to the activities of the six working groups, task forces, and Arctic Council assessments, like the 2009

Arctic Marine Shipping Assessment. Financial contributions vary significantly from country to country. As the United States assumes the chairmanship of the Arctic Council in April 2015, the United States will continue to contribute financially and through in-kind participation in working groups and task forces, but it is unclear whether additional budgetary resources will be made available.

Role in Scientific Cooperation

The United States is a science power in the Arctic and strengthening scientific cooperation is identified as a key goal of U.S. Arctic policy. The 2009 National Security Presidential Directive (NSPD-66) identified the development of international scientific cooperation as a primary goal, as well as ensuring environmental protection and conservation. The 2013 National Strategy for the Arctic Region also includes the priority "Pursue Responsible Arctic Region Stewardship," calling for the protection of the Arctic environment and conservation of its resources, and the employment of scientific research to increase understanding of the region. Through a variety of organizations, such as the National Science Foundation, the U.S. Arctic Research Commission, the National Oceanic and Atmospheric Administration (NOAA), and even the National Aeronautics and Space Administration (NASA), the United States has conducted extensive scientific research on the polar regions and in 2013 spent approximately $1 billion on science and research.[a]

a The $1 billion figure is an estimate based on the following budgets, as well as those from other U.S. government agencies and organizations. (1) National Science Foundation FY2014 budget was approximately $435.8 million, http://www.nsf.gov/about/budget/fy2014/pdf/EntireDocument_fy2014.pdf. (2) United States Arctic Research Commission budget was $1.45 million, https://www.nsf.gov/about/budget/fy2014/pdf/24_fy2014.pdf. (3) NASA spent roughly $207 million for ICESat-2 and $6 million for the Suomi NPP satellite, http://www.nasa.gov/pdf/740512main_FY2014%20CJ%20for%20Online.pdf. (4) NOAA spent $824,000 on the Joint Polar Satellite System, nearly $29,000 on Polar Orbiting Systems, $62,000 on the Polar Free Flyer; NOAA also requested a budgetary increase of $2.05 million for Arctic marine ecosystem research, as well as budgetary increases of roughly $31 million for projects that include Arctic research components, http://www.corporateservices.noaa.gov/nbo/fy14_bluebook/FINALnoaaBlueBook_2014_Web_Full.pdf. (5) The Department of Interior's Bureau of Ocean Energy Management spent $1.1 million for an air quality regulatory program in Alaska and Bureau of Safety and Environmental Enforcement spent $1.4 million on oil spill research, http://www.doi.gov/budget/appropriations/2014/highlights/upload/2014_Highlights_Book.pdf. (6) The National Institutes of Health from 2009 to 2012 annually spent $31 million on Arctic projects, http://www.whitehouse.gov/sites/default/files/microsites/ostp/2013_arctic_research_plan.pdf.

Internationally, the Arctic Council has been one of the most important venues for strengthening scientific and research cooperation. Since its creation in 1996, the Arctic Council has studied key Arctic environmental and sustainable development issues, such as assessments and monitoring of Arctic biodiversity, and strives to develop actionable strategies to protect and preserve the Arctic environment and its populations. In 2013, the Arctic Council established the Scientific Cooperation Task Force, which is currently working toward an international agreement to enhance scientific research cooperation. The task force builds its work around science priorities set by independent science bodies, such as the University of the Arctic and the International Arctic Science Committee. A great deal has already been achieved through international cooperation in the Arctic Council, including research on pollutants such as black carbon and methane, the Arctic Council's Agreement on Cooperation on Marine Oil Pollution, Preparedness and Response, improving the health and well-being of Arctic indigenous communities, and climate change assessments.

Role in Oil and Gas Development

There are two working groups in the Arctic Council that deal directly with oil and gas issues. The first is the working group on Protection of the Arctic Marine Environment (PAME). In 2009, PAME produced its Offshore Oil and Gas Guidelines report. In 2014, it produced a set of guidelines to supplement this report, on systems safety management and safety culture. The second working group is on Emergency Prevention, Preparedness, and Response (EPPR). In 2013, EPPR produced a paper on recommended practices for the prevention of oil pollution in the Arctic.

The PAME working group deals with all Arctic Council activities related to the sustainable development in the Arctic marine environment. It has the specific mandate of keeping under review the adequacy of global and regional legal, policy, and other measures, and where necessary, of making recommendations for improvements that support the Arctic Marine Strategic Plan. PAME developed the first set of guidelines for Arctic offshore oil and gas activities. These guidelines define a set of recommended practices and outline strategic actions to be considered by policymakers responsible for oil and gas activities in the Arctic. The guidelines are nonbinding, but encourage the highest standards currently available. PAME has been one of the primary Arctic Council drivers for using an integrated ecosystem-based approach to management that recommends development activities be coordinated in a way that minimizes their impact on the environment and integrates thinking across environmental, socioeconomic, political, and sectorial realms. Development activities need to be focused on realistic, practical steps that are directed toward reducing environmental degradation, protecting biodiversity, and promoting the health and prosperity of local communities. PAME also produced the Arctic Marine Shipping Assessment (AMSA) in 2009. One recommendation from the AMSA was to make mandatory the International Maritime Organization's (IMO) Polar Code for maritime operations in the Arctic. This code has been under review for nearly a decade but will likely be approved in 2015. PAME has also undertaken a project to identify risks associated with vessel use and carriage of heavy fuel oil in the Arctic and the possible effects of a spill on the environment.

EPPR was set up as a working group under the Arctic Council's precursor, the Arctic Environmental Protection Strategy, and it continues today as a working group under the Arctic Council. The mission of EPPR is to foster international cooperation on environmental protection and sustainable development in the Arctic. The working group was instrumental in the development of a set of operational guidelines that are part of the Agreement on Cooperation on Marine Oil Pollution Preparedness and Response. Their current work is on improving prevention measures, emergency preparedness, response capabilities, and information sharing.

The EPPR working group was tasked to develop draft operational guidelines in support of the Oil Spill Response and Prevention Agreement that was signed at the Kiruna Ministerial meeting in 2013. The objective of the agreement is to strengthen cooperation, coordination, and mutual assistance among the parties on oil pollution preparedness and response to protect the Arctic marine environment from pollution from oil. The agreement requires each Arctic nation to maintain a system for responding promptly and effectively to incidents and to work with the oil and shipping industries, port authorities, and other relevant entities to maintain a minimum level of prepositioned oil spill response equipment, maintain training of personnel, and develop a communications plan to respond to an incident. Operational guidelines, developed as part of the agreement, were revised in January 2014 to add procedures for updating the operational guidelines.

There are also other task forces and working groups that are undertaking work or developing agreements that may prove relevant to prudent development of the Arctic, including the Task Force on Arctic Marine Oil Pollution Prevention, the Task Force on Black Carbon and Methane, and the Sustainable Development Working Group.

The Arctic Economic Council

The Arctic Economic Council (AEC), created during the Canadian chairmanship of the Arctic Council with significant support from a number of member nations, is intended to provide a forum to discuss the economic development of the Arctic region and to allow for the inclusion of the business community in those discussions. While there was support for the creation of this forum from numerous Arctic Council member nations and the business community, not all members believed the Arctic Council's mandate should have been broadened to include this initiative.

To facilitate the creation of the AEC, a task force was created to promote sustainable economic and social development as well as environmental protection. The task force submitted its report to the Senior Arctic Officials (SAOs) for their amendment and approval with the hope that the AEC could begin its work in early 2014. However, due to a number of issues, approval was not forthcoming until the SAO meeting in Yellowknife, Northwest Territories, Canada, on March 26, 2014.

The overall aim was amended to include the fostering of environmental protection and social development in the Arctic as well as sustainable development, including economic growth. The SAOs deleted an implementation item, "Following the work of, collaborating with, and informing the Arctic Council, while seeking the perspectives of those interested in Arctic business and economic development," and restricted the interaction of the AEC directly with the Arctic Council by allowing interface only "pursuant to Rules 39 and 40 of the Arctic Council Rules of Procedure." They also changed the number of representatives that would be sent to the founding meeting.

The Canadian Minister, the Honorable Leona Aglukkaq, announced on July 10, 2014, that she would host the initial organizational meeting of the AEC in Iqaluit, Nunavut, September 2-3, 2014. She also named Canada's three representatives at that time. Prior to this, the United States had chosen not to nominate representatives to the AEC and, after consultation with the U.S. SAO, Aglukkaq invited the Alaska State Chamber of Commerce, in collaboration with the Alaska Arctic Policy Commission (AAPC) cochairs, to name three representatives for the United States and Alaska. The three U.S. nominees, as well as an alternate, were duly chosen and were also announced by the Alaska State Chamber and AAPC on July 10, 2014. Since July 2014, most of the member country and permanent participant nominees have been named. The United States is also represented by a number of permanent participant nominee representatives, from the Inuit Circumpolar Council, the Aleut International Association, the Arctic Athabaskan Council, and the Gwich'in Council International.

Many nations and the business community have recognized the potential of the AEC to encourage sustainable economic and social development of the Arctic. The Scandinavian nations in particular have supported the AEC, with Norway indicating that they would be willing to contribute financially to the establishment of the AEC Secretariat. The future efficacy of the AEC will depend greatly on the participation of the member nations, the business community, and local indigenous groups and populations.

See Chapter 4 for recommendations with regards to U.S. participation in and chairmanship of the Arctic Council.

CHALLENGES TO IMPLEMENTING NSAR/IPNSAR GOALS

Policy Coordination

Since 1971, when President Nixon issued NSDM-144 and assigned responsibility to seven federal agencies (the Departments of State, Defense, Interior, Commerce, and Transportation, as well as the director of the National Science Foundation and the chairman of the Council on Environmental Quality),[9] the number of federal agencies involved in Arctic policy formation has grown significantly. By 2009, when President George W. Bush issued his Arctic directive, "twenty-four separate departments, agencies, and offices"[10] were tasked with Arctic responsibilities. Today, U.S. government activity on the Arctic is housed within at least 39 federal agencies and organizations—39 is the number of federal agencies that participate in the Arctic Policy Group, an organization led by the Department of State that discusses issues, shares information, and convenes monthly. In addition, the IPNSAR notes that there are other interagency organizations with authority over Arctic policy, giving the National Ocean Council and the Interagency Arctic Research Policy Committee as two other examples. The text box on the next page lists the 27 agencies, working groups, and committees that are identified as having responsibility under President Obama's IPNSAR.

Even with regard to Arctic oil and gas development alone, there are numerous federal agencies with some level of ownership. The Department of the Interior, which is responsible for leasing and regulation of U.S. Arctic oil and gas development, is likely the agency with the most influence over Arctic policy as it concerns oil and gas on federally managed areas, but it is by no means the only agency. The U.S. Coast Guard and the Environmental Protection Agency both have jurisdiction over oil spills (offshore and onshore respectively), with the assistance of the other federal agencies that make up the U.S. National Response Team. The National Oceanic and Atmospheric Administration and the Department of Energy maintain roles related to scientific research and technology development. In addition, the Department of State maintains jurisdiction over diplomatic efforts, including those related to energy, with the assistance of the agencies that lead delegations to Arctic Council working groups and task forces.

In addition to the federal departments, agencies, and offices with a role in Arctic policy formation, Congress and state, local, and tribal groups share those interests and responsibilities, further complicating coordination of Arctic policy development. Coordination of so many stakeholders that represent a wide variety of interests, goals, and guiding principles is extremely challenging.

In March 2014, Secretary of State John Kerry announced a newly created position, a U.S. Special Representative for the Arctic Region, and appointed recently retired Coast Guard Commandant Admiral Robert Papp to the position in July 2014. This

Federal Agencies Identified in the Implementation Plan for the National Strategy for the Arctic Region

Departments and Agencies (23)

- Department of Agriculture
- Department of Commerce
- Department of Commerce (National Oceanic and Atmospheric Administration)
- Department of Commerce (National Telecommunications and Information Administration)
- Department of Defense
- Department of Energy
- Department of Health and Human Services
- Department of Homeland Security
- Department of Homeland Security (United States Coast Guard)
- Department of the Interior
- Department of the Interior (United States Geological Survey)
- Department of State
- Department of Transportation
- Department of Transportation (Federal Aviation Administration)
- Department of Transportation (Maritime Administration)
- Environmental Protection Agency
- Federal Communications Commission
- National Aeronautical and Space Administration
- National Maritime Intelligence-Integration Office
- National Science Foundation
- Office of Science and Technology Policy
- Smithsonian Institute
- U.S. Arctic Research Commission

Interagency Groups (4)

- Aquatic Nuisance Species Task Force
- Committee on the Marine Transportation System
- National Invasive Species Council
- United States National Response Team

position does not hold the rank of Ambassador and is not confirmable by the U.S. Senate. The Special Representative reports to Secretary Kerry and is responsible for coordinating U.S. policy as it relates to the upcoming U.S. chairmanship of the Arctic Council. The United States assumes the 2-year chairmanship of the Arctic Council in April 2015, which lasts until May 2017. It is unclear if the Special Representative position will have broader policy responsibilities beyond the Arctic Council.

Despite the leading position of the Department of State of coordinating international issues related to the Arctic, there are also seven interagency Arctic policy coordinating groups, identified in the text box on U.S. interagency Arctic policymaking bodies.[11] Figure 3-1 highlights the key players in Arctic mineral and energy policy. The long-standing White House Interagency Policy Committee on the Arctic convenes at the assistant secretary-level and serves as a coordinating body for existing activities and initiatives rather than actively leading new policy formulation. The Interagency Working Group on Coordination of Domestic Energy Development and Permitting in Alaska, is led by the Deputy Secretary of Interior, and specifically coordinates the efforts of the agencies responsible for oil and gas development on federal lands in Alaska, including the offshore Arctic.

The need to improve the internal organization of federal agency activities is particularly relevant as the United States approaches its chairmanship of the Arctic Council. A 2014 report by the U.S. Government Accountability Office (GAO) cited concerns from government stakeholders that there was a lack of clear direction for U.S. engagement and participation with the Arctic Council and limited efforts to prioritize and effectively communicate ongoing work. The report also cited concerns about the ability of federal agencies to consistently participate in Arctic work, specifically with regards to the Arctic Council, due to the lack of budget resources specifically allocated to those projects. In short, stakeholders reported that while the NSAR does exist, in addition to numerous agency Arctic strategies, these documents do not articulate an overall approach for agencies to follow in Council participation.

In its report, the GAO makes several recommendations for how the United States can better direct and manage its participation in the various Arctic Council working groups and task forces. The report

U.S. Interagency Arctic Policymaking Bodies

Arctic Policy Group. This is a working-level interagency group chaired by the State Department, and it primarily coordinates U.S. activities in and input to the Arctic Council. All federal agencies that have institutional interests in the Arctic participate in monthly meetings.

Interagency Arctic Research Policy Committee. This group is chaired by the National Science Foundation and was authorized by the 1984 Arctic Research Policy Act to develop and coordinate the U.S. policy for Arctic research.

Interagency Coordinating Committee on Oil Pollution Research. Established as part of the Oil Pollution Act of 1990 to: "…coordinate a comprehensive program of oil pollution research, technology development, and demonstration among the federal agencies, in cooperation and coordination with industry, universities, research institutions, state governments, and other nations, as appropriate, and shall foster cost-effective research mechanisms, including the joint funding of the research."

Interagency Working Group on Coordination of Domestic Energy Development and Permitting in Alaska. Created in July 2011 and chaired by the deputy secretary of the Department of the Interior, this group brings together the federal agencies and departments responsible for overseeing onshore and offshore drilling in Alaska to coordinate the permit process when multiple agencies are involved in a project.

Interagency Policy Committee on the Arctic. This is an assistant secretary-level interagency group chaired by the National Security Staff to coordinate Arctic policy implementation within the executive branch.

Maritime Security Working Group. This group is chaired by the assistant to the president for homeland security and, on occasion, focuses on the maritime security environment in the Arctic.

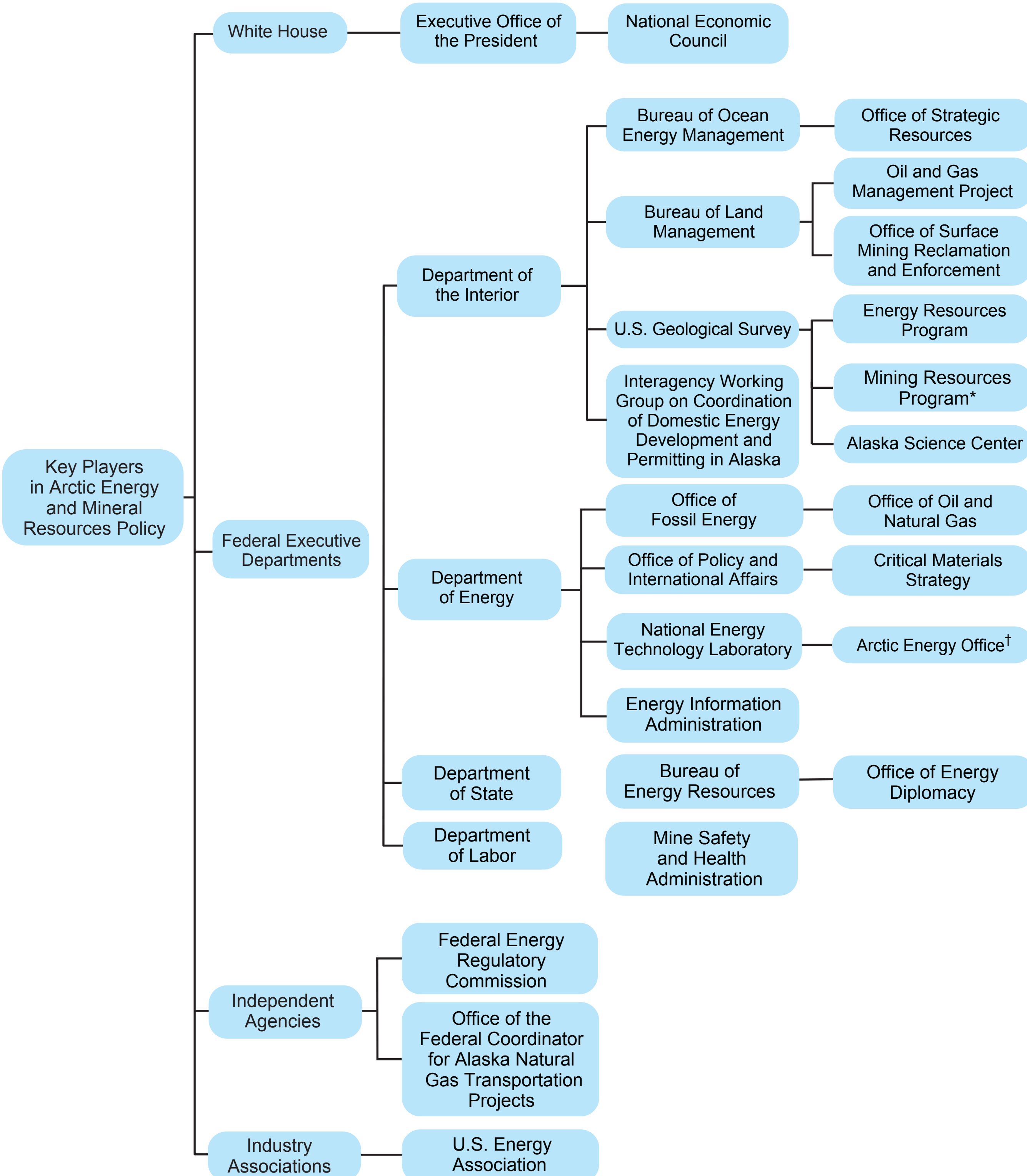
National Ocean Council. Cochaired by the Office of Science and Technology Policy and the Council on Environmental Quality, and directed to implement the National Ocean Policy, this interagency group on occasion discusses Arctic related issues. This council is home to two subcommittees, the Ocean Resource Management Interagency Policy Committee and the Ocean Science and Technology Interagency Policy Committee.

calls for the Secretary of State to take three actions: (1) work with other agencies to develop a joint strategy that guides U.S. participation in the Arctic Council and identifies the resources needed to sustain "collaborative efforts and consistent participation;" (2) develop a process by which the Department of State can review and track agency progress toward implementing voluntary recommendations from the Arctic Council (a process that has already been initiated during the Canadian chairmanship); and (3) work with other Arctic States to develop guidelines that will ensure the production of clear recommendations with measurable actions and then to prioritize those recommendations. The State Department has made strides toward the first recommendation, through the interagency Arctic Policy Group, but additional resources have not been identified.

The GAO report reveals that despite the release of the NSAR and its implementation plan, there is still a lack of clear guidance on U.S. priorities in the Arctic. Limited resources, both financial and human, impact the ability of the United States to adequately engage on Arctic issues.

Budget

U.S. Arctic policy formation is complicated and constrained by budget challenges. Federal budget levels have been constant since 2008. As a result, many agencies, particularly those relatively new to the arena of Arctic policy, are forced to prioritize new tasks and responsibilities within existing budgets, with little or no new funding for personnel or projects. This is problematic for the development and implementation of cohesive and effective national Arctic policies. In addition to the multiple challenges of articulating a coherent Arctic policy with so many stakeholders to engage, scientific research, technology development, support of commercial activities



* The Mining Resources Program runs the National Minerals Information Center.

† The Arctic Energy Office is part of the Strategic Center for Natural Gas and Oil.

Source: Heather Conley, *The New Foreign Policy Frontier: U.S. Interests in the Arctic,* Center for Strategic & International Studies, March 2013.

Figure 3-1. *Key Players in Arctic Energy and Mineral Resources Policy* with infrastructure, and emergency response are all also undertakings that cannot be achieved without budgetary support.

LESSONS LEARNED FROM OTHER ARCTIC NATIONS

Many other Arctic nations are engaged in efforts to balance energy security, economic development, and environmental stewardship and to establish bilateral and multilateral programs to complement national efforts. The United States has partnered bilaterally with both Russia and Canada to create the Canada-U.S. Joint Marine Pollution Contingency Plan and the Russia-U.S. Joint Contingency Plan Against Pollution in the Bering and Chukchi Seas, which "provide frameworks for the respective governments to cooperate in establishing measures and mechanisms to prepare for and respond to pollution incidents."[12] Industry organizations have also been deeply engaged in standard setting efforts to ensure learning applied in one environment can be understood and considered in other environments.

Cooperation on Standards and Best Practices

Throughout the history of oil and gas industry activity offshore, both in the Arctic and elsewhere, advancements have been made in technology and operating practices, best practices have been identified, and standards have been set by independent organizations, multilateral organizations, and industry groups. Many of these standards have been set by well-respected organizations and have been designed to ensure that development of resources is done prudently. A full examination of these standards and best practices, many of which are identified in the text box on international cooperation on Arctic standards, could assist the nation in creating regulations, expectations, and standards that incorporate the full range of existing knowledge and experience, best ensuring prudent development of U.S. resources.

Alternative Approaches to Economic Development

The communities where the resource is located and developed, as well as state and federal stakeholders, should have the opportunity to share in the economic benefits of prudent development. There are many approaches to delivering these economic benefits. Several existing models from jurisdictions both within and outside of the United States are discussed below.

Revenue Sharing in the U.S. Gulf of Mexico

Revenue sharing in the U.S. Gulf of Mexico was made law in 2006, as the result of the Gulf of Mexico Energy Security Act (GOMESA). The purpose of the act was to ensure that the states of the Gulf Coast would share in the revenues generated by resource development that takes place in the federal waters off their shores.[13] The first phase of GOMESA allowed for 37.5% of Outer Continental Shelf revenues (to include bonus bids, rentals, and production royalties) to be shared among the four coastal states from two specified sections of the Gulf Coast lease area and is to be expanded in a second phase to include most leases within the Gulf of Mexico program area. Revenue sharing was intended to spur local economic development, and according to Department of Interior officials, resulted in the disbursement of more than $29.4 million between 2009 and 2013.[14]

CanNor

CanNor, the Canadian Northern Economic Development Agency, is one example of government driven economic development in the Arctic. CanNor, established in 2009, works to help develop a diversified, sustainable, and dynamic economy across Canada's three territories, while at the same time contributing to Canada's prosperity. CanNor fosters growth and development in the North by delivering economic development programs and by collaborating with and aligning the efforts of partners in northern and southern Canada to respond to economic challenges and opportunities in the North.

The agency also coordinates the activities of other federal departments to maximize their collective impact—particularly federal regulators in relation to major project development in the North—bringing insight, knowledge, and partnerships together and has three key, interrelated business lines and services that help drive economic development: contribution programs, the Northern Projects Management Office, and serving as a voice for the North.

The Northern Projects Management Office (NPMO) provides issues management, pathfinding, and advice

International Cooperation on Arctic Standards Affecting Oil and Gas Operations

There are a number of international conventions, standards, class society rules, and guidelines either in place or under development that are of importance to Arctic oil and gas exploration and development.

Of note are the following:

- The International Maritime Organization (IMO) has approved its "International Code for Ships Operating in Polar Waters" Polar Code covering all shipping in polar waters. The code covers the full range of design, construction, equipment, operational, training, search and rescue, and environmental protection matters relevant to ships operating in the inhospitable waters surrounding the two poles. The code is expected to come into force in 2017 and would impact supply and support vessels used to support exploration and development drilling operations. The Polar Code provisions will not apply to drill rigs, given IMO's focus on ship-focused instruments; however, drillships in transit would be expected to comply.
- The International Association of Classification Societies has published construction and equipment standards for Polar Class vessels, again with variations for the ice conditions within a vessel's area and seasonality of operations.
- The Oil Companies International Marine Forum has recently published guidelines on vessel operations in Arctic-like conditions, *Offshore Vessel Operations in Ice and/or Severe Sub-Zero Temperatures in Arctic or Sub-Arctic Regions* (2014). This document enumerates recommendations on technical specifications for vessels, operating practices and safety, and environmental considerations, including oil spill response.
- The International Standards Organization (ISO) has developed standard 19906 for fixed and floating offshore structures operating in Arctic conditions in support of oil and gas operations. Although the standard explicitly excludes mobile offshore drilling units (MODUs), it does specify that ice management procedures in the standard should also be applicable to MODUs.
- ISO Technical Committee 67/SC8 is developing a set of standards for Arctic oil and gas operations, including working environment; escape, evacuation, and rescue; environmental monitoring; ice management; Arctic materials; and physical environment for Arctic operations.
- The Kiruna Declaration signed in May 2013 by Arctic Council member states provides for the sharing of oil spill response resources between countries and movement of people and equipment across borders. Included with the declaration was the Agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic. The objective of this Agreement is to strengthen cooperation, coordination, and mutual assistance among the parties on oil pollution preparedness and response in the Arctic in order to protect the marine environment from pollution by oil. Requests for and provision of assistance, facilitation of movement of equipment across borders, cooperation and exchange of information, joint exercises, and training are also topics of this agreement.
- The Arctic Council's Task Force on Pollution Prevention is progressing an action plan that establishes a framework for cooperation on oil spill prevention across Arctic states. The action plan is supported by a measures document that provides specific implementation detail. With respect to the oil and gas industry, the petroleum measures document calls for specific action in three areas: baseline overview of work ongoing for prevention, support for standardization, and creation of an Arctic Regulators Forum.

to industry and communities; coordinates the participation of federal departments in the regulatory review process; and publicly tracks the progress of projects to bring transparency, timeliness, and effectiveness to the regulatory system. NPMO works with partners to advance community readiness, helping to maximize the positive socioeconomic impacts of major projects on northern communities.

CanNor's suite of programs provide funding to support the development of key economic sectors such as mining, tourism, fisheries, cultural industries, and community and business development. The programs include: Strategic Investments in Northern Economic Development, Northern Aboriginal Economic Opportunities Program, Northern Adult Basic Education Program, Community Infrastructure Improvement Fund, and promotion of official language minority communities.

Denali Commission

The Denali Commission is a federal agency that was created by the U.S. Congress "to provide critical utilities, infrastructure, and economic support throughout Alaska,"[15] with a particular focus on remote Alaskan communities. The Denali Commission is a successful example of an interagency organization focused on infrastructure and economic development. Of particular interest to this study is the Commission's Energy Program, which funds energy infrastructure projects including Transportation and Distribution systems, community power generation and bulk fuel storage. The Denali Commission has traditionally been funded through federal funds, primarily from the Energy and Water Appropriations Committee, but the legislation creating the commission has recently been expanded to allow funding from other agencies. The commission also "receives funds from sources such as the U.S. Department of Agriculture and from the Trans-Alaska Pipeline Liability trust fund for energy projects."[16]

Challenges to Further Cooperation

The Arctic is a rapidly transforming ecosystem where international cooperation is necessary, and the decisions and activities implemented by one Arctic coastal state can have a lasting impact on all Arctic nations. Geopolitical tension, such as the deterioration in relations between Russia and the West ongoing at the time of writing, could potentially jeopardize this essential cooperation and coordination. Diplomatic cooperation depends on a delicate balance of interests and politics and can be strongly affected by seemingly unrelated incidents and events. Similarly, any militarization of the Arctic could have a similarly negative impact. In the case of the Arctic, deterioration of cooperation would have a negative effect not only on the diplomatic side of the Arctic Council, but also on the scientific research, technology development, economic development, and joint safety operations that are undertaken under its auspices.

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Chapter 4

Policy and Regulatory Opportunities to Promote Prudent Development

SCOPE

This chapter provides recommendations in seven areas for suggested policy and regulatory improvements that would enable economic, prudent exploration and development. The following topics are discussed, including reference to the relevant research and technology chapters in this report.

- Recommendations specific to the Arctic Council, opportunities for improved coordination in both policy and regulatory arenas, and consideration of performance-based regulations. As discussed in Chapter 3, the need for improved coordination among all agencies active in oil and gas is readily apparent and even more important in the context of the upcoming U.S. chairmanship of the Arctic Council.
- Specific recommendations on regulations that do not allow the best solution to be brought to bear and where the United States differs significantly from other jurisdictions—four examples are:
  1. Season length that is constrained by policy and not by the technical capability of the drilling rig and system used
  2. Lease terms not commensurate with the realities of working in the Arctic
  3. Overly broad critical habitat designations that restrict oil and gas activities without offering environmental stewardship benefits
  4. Specific regulations that restrict land access or hydrocarbon transportation options and do not promote access to efficient and effective infrastructure and logistics.

INTRODUCTION

As was done in both National Petroleum Council (NPC) reports, *U.S. Arctic Oil and Gas* (1981) and *Prudent Development* (2011), and with an understanding that increased development of U.S. Arctic oil and gas resources can only be realized if developed prudently, policy and regulatory recommendations have been provided based on analysis of hundreds of existing studies and input from many organizations.

Continued development of Arctic energy resources is not guaranteed. Despite the release of numerous U.S. Arctic strategies, implementation plans, and assessments, very few Americans recognize that the United States is an Arctic nation—making it difficult to build momentum in favor of public policy initiatives. While both the U.S. government and other Arctic countries acknowledge the importance of prudent development, some countries place greater emphasis on oil and gas resource development, thus creating an uneven approach to development in the circumpolar Arctic. For the United States, some stakeholders are hesitant to fully support development of offshore energy resources in the U.S. Arctic as policy questions linger following the 2010 Gulf of Mexico oil spill and in light of the perceived fragility of the Arctic ecosystem. Adding complexity are the 39 federal agencies that participate in the Arctic Policy Group—a dramatic increase from the seven named when President Nixon issued the first directive for federal government coordination of Arctic policy. An improved framework for prudent resource development in the Arctic should be undertaken to encourage all stakeholders, including the U.S. government, foreign governments, local communities, industry, and interested stakeholder groups, to have confidence in the process of Arctic resource development.

These recommendations suggest how such an improved framework could be adopted to address broader policy issues, a cohesive approach to U.S. participation in the Arctic Council, increased cooperation between government and nongovernment stakeholders, improved regulatory function, and support for scientific research and technology development. Several policy issues follow directly from the NPC's 2011 *Prudent Development* study. Fundamental to all of these issues is a commitment by both companies and regulators to excellent environmental performance and continuous improvement informed by local traditional knowledge. All of these organizations should ensure that their operations evolve and keep pace with the development of new and highly effective practices.

OPPORTUNITIES TO PROMOTE PRUDENT DEVELOPMENT

Using the U.S. Arctic Council Chairmanship Can Promote Prudent Arctic Resource Development

The U.S. government has proposed that its chairmanship of the Arctic Council be branded "One Arctic: Shared Opportunities, Challenges and Opportunities." The proposed efforts of the chairmanship are to be focused within three organizational areas: (1) Addressing the Impacts of Climate Change in the Arctic; (2) Stewardship of the Arctic Ocean; and (3) Improving Economic and Living Conditions. These goals are compatible with the call for prudent development of Arctic resources, and this study has sought to explore how U.S. offshore Arctic resources can be developed while also ensuring stewardship of the Arctic Ocean.

As a platform designed to focus on the economic development of the Arctic, connecting business leaders from numerous industries with Arctic policymakers, the Arctic Economic Council could provide a key opportunity for industry engagement with the Arctic Council. Such engagement could help to close the existing knowledge gap regarding economic development in the Arctic, allowing numerous stakeholders, including foreign governments, local governments, and representatives from the business community, to engage on development issues.

Recommendations

- As Arctic Council members implement the two internationally legally binding agreements on search and rescue (2011) and on oil pollution preparedness and response (2013), the U.S. government should encourage engagement and participation with the international energy industry in the conduct of its search and rescue table top exercise in May 2015 and the full-scale exercise in the summer of 2016.
- The U.S. government should seek to strengthen the Arctic Economic Council's formal interaction and engagement with the Arctic Council as well as to promote its business advisory role.
  - The Arctic Economic Council should consider all aspects of business and economic development, including, but not limited to, science and traditional knowledge, quality employment, capacity building, partnerships with local businesses, and the promotion of best practices among all those operating in the Arctic.
  - This is in line with the 2013 Kiruna Declaration, which acknowledged the central role of business in the future sustainable development of the Arctic for the benefit of all in the region.
- The U.S. government should provide engaged federal agencies with sufficient financial support to fulfill their obligations to the Arctic Council in order to maximize their effectiveness during the U.S. chairmanship (2015-2017), as well as to ensure that the beneficial research efforts undertaken by the Arctic Council working groups and task forces continue.

Enhanced Coordination and Capacity in Regulatory Agencies Can Facilitate Prudent Arctic Resource Development

Enhanced Policy Coordination

As discussed in Chapter 3, the fact that at least 39 federal agencies have responsibilities in the Arctic region is a challenge for successfully implementing national strategies and achieving national objectives with regards to the Arctic. To be most effective, the president and the executive branch must actively promote high-level interagency policy coordination and direction. Designating a senior official to lead domestic and international Arctic policy that goes well beyond a coordinating function during the 2-year chairmanship of the Arctic Council could help address this challenge. The Arctic Executive Steering Committee, established in January 2015 by executive order is a step in this direction, as discussed in Chapter 3. Because the next 4 years will be decisive for U.S. Arctic policy development, the 32-page-long Implementation Plan for the National Strategy for the Arctic Region must be prioritized, tasking streamlined, and budget resources allocated.

Enhanced Regulatory Coordination and Capacity

This study has confirmed the conclusions of previous studies—including the NPC's 2011 *Prudent Development* report and, more specifically, the Arctic supply topic paper prepared in conjunction with that report—that multiple, overlapping regulatory agencies with, in some instances, conflicting regulatory objectives bring a high level of uncertainty, additional cost, and delay to permitting processes and the predictability of regulatory oversight. This complexity and uncertainty puts at risk current and future prudent development of oil and gas resources in the U.S. Arctic, since it is unlikely operators will be able to commit to the high level of investments needed to carry out their exploration programs without sufficient confidence that regulatory processes can be complied with in a reasonable and predictable time frame, consistent with lease term offerings. Figure 4-1 and Figure 4-2 show the principal agencies and bodies responsible for regulation, oversight, or consultation regarding oil and gas activities in Alaska, from the federal, state, and local level, including agencies and bodies involved at each stage of the life cycle of exploration and development for an offshore Outer Continental Shelf (OCS) project in Alaska.

Large-scale projects can take several years to secure all the relevant permits, with the complexity of the system opening up multiple opportunities for legal challenge, furthering delay. National Environmental Policy Act and Environmental Impact Statement requirements and time frames are particularly costly and onerous. Lack of coordination between agencies results in uncertainty of outcomes for operators and other stakeholders.

In 2011, by Executive Order 13580, the Interagency Working Group on Coordination of Domestic Energy Development and Permitting in Alaska (IAWG) was established to promote interagency communication with respect to permit applications and timelines. This body is headquartered in Washington, D.C. and has a regional office in Alaska (RIAWG), in which both federal and state bodies participate. The working group is chaired by the Department of Interior (DOI) and includes representatives from the Department of Defense, Department of Commerce, Department of Agriculture, Department of Energy (DOE), Department of Homeland Security, Environmental Protection Agency, Federal Coordination Office for Alaska Natural Gas Transportation, Council on Environmental Quality, Office of Science and Technology Policy, Office of Management and Budget, and National Security staff. Participants in this NPC study have commended these bodies for their real improvements in communication, but have pointed out that real coordination of regulatory objectives and timelines can continue to be improved and have expressed concerns about this group's ability to handle an additional level of permitting.

There is potential for the work of the IAWG and the RIAWG to enable more effective and timely permitting by identifying gaps, eliminating outdated and/or overlapping requirements, and harmonizing permitting timelines. A framework for undertaking the analysis required to identify specific regulatory improvements exists in the Government Performance and Results Act (GPRA). The GPRA was originally passed in 1993 and updated in 2010. It is designed to require government agencies to adopt a rigorous, structured process to set performance improvement goals, establish plans to implement the goals, and report on results. This includes provisions for setting cross-agency objectives, with targeted outcomes and transparent reporting of achievements against targets. The Office of Management and Budget (OMB) is tasked with preparing an annual report on agency performance under the GPRA process. It would therefore be appropriate for the OMB as a member agency in the IAWG, to play an important role in facilitating this process of identifying and implementing regulatory improvements.

Other Arctic jurisdictions, including other countries and the state of Alaska, appear to have a more coordinated approach to Arctic regulation and permitting of oil and gas activities as follows:

- Norway (Norwegian Petroleum Department and Petroleum Safety Agency) and Canada (National

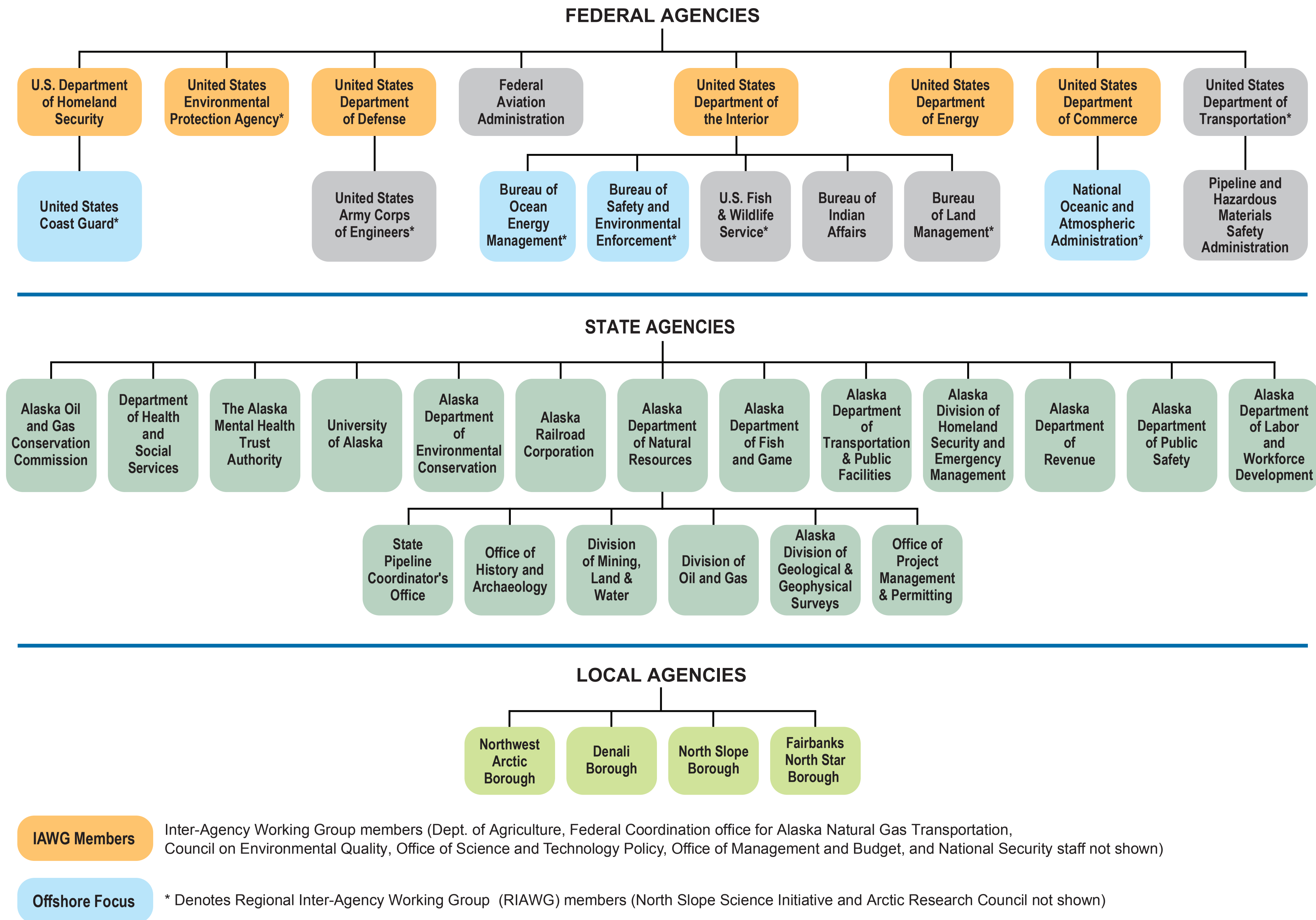


Figure 4-1. *U.S. Federal, State, and Local Agencies Involved in U.S. Arctic Oil and Gas Activities*

1. Lease Land
- BOEM – OCSLA – Lease Sale
- Lease Stipulations[1]
- NEPA review[2] (conducted by agency)
  - Includes review of multiple applicable laws
- Reviewed by State of Alaska for consistency with state laws
- Reviewed by BSEE for technical and safety content

2. Seismic Acquisition
- BOEM – OCSLA – A&A
  - NEPA review[2] (conducted by agency)
- BOEM – OCSLA – G&G
  - NEPA review[2] (conducted by agency)
- BOEM – OCSLA – NTLs for seismic acquisition
- BOEM – OCSLA – Lease stipulations[1]
- EPA – CWA – NPDES Vessel General Permit
  - Vessel discharges
- NOAA/NMFS, USFWS – MMPA – Authorizations
  - NEPA review[2] (conducted by agency)
  - 4MP
  - IHAs / LOAs (as appropriate)

3. Site Selection
- BOEM – OCSLA – A&A and SHS[3] (On-Lease Activities)
  - NEPA review[2] (conducted by agency)
- BOEM – OCSLA – G&G and SHS[3] (Off-Lease Activities)
  - NEPA review[2] (conducted by agency)
- BOEM – OCSLA – Lease stipulations[1]
- EPA – CWA – NPDES General Permit
  - For geotechnical activities
- EPA – CWA – NPDES Vessel General Permit
  - Vessel discharges
- NOAA/NMFS, USFWS – MMPA – Authorizations
  - NEPA review[2] (conducted by agency)
  - 4MP
  - IHAs / LOAs (as appropriate)
- ADEC – CWA – APDES General Permit
  - For geotechnical activities in State of Alaska waters

4. Local Considerations
- ADNR – LUP
- NSB – Title 19 Zoning
- NWAB – Title 9 Zoning
- Industry – Local Stakeholder Engagement Methods
  - AEWC – CAA
  - Subsistence mitigation
  - Marine mammal co-management meetings
  - POC meetings
- Native allotment owners

5. Exploration Drilling
- BOEM – OCSLA – EP/EIA
  - NEPA review[2] (conducted by agency)
- BOEM – OCSLA – Lease stipulations[1]
- BSEE – OCSLA – APD
- BSEE safety regulations
  - NTLs
  - OSRP
  - COCP
  - BOP certification/recertification
  - WCD
  - DIMP
- EPA – CWA – NPDES General Permit
  - Drilling activities
- USACE – NWP #8
- USCG – Safety and Security Zones
- NOAA/NMFS, USFWS – MMPA – Authorizations
  - NEPA review[2]
  - 4MP
  - IHAs/LOAs (as appropriate)

6. Development and Production Plan
- BLM – Certificates of Public Convenience
  - NEPA review[2] (conducted by agency)
- BOEM – OCSLA – Development and Production Plan
  - NEPA review[2] (conducted by agency)
- BSEE – OCSLA
  - APDs
  - OSRP
  - DOCD
- EPA – CWA – NPDES General Permit
  - Development activities
- USACE – Section 404 Permit
  - NEPA review[2] (conducted by agency)
- JPO-SPCO – ROW
  - ADNR – LUP
  - NSB – Title 19 Zoning
- NOAA/NMFS, USFWS – MMPA – Authorizations
  - NEPA review[2] (conducted by agency)
  - 4MP
  - IHAs / LOAs (as appropriate)
- Disposal and Injection Well Permits (APD from BSEE; UICS, NPDES from EPA)

NOTES
[1] OCS Lease Stipulations include:
1. Protection of Biological Resources
2. Orientation Program
3. Transportation of Hydrocarbons
4. Industry Site-Specific Bowhead Whale Monitoring Program
5. Conflict Avoidance Mechanisms to Protect Subsistence Whaling and Other Marine Mammal Subsistence Harvesting Activities
6. Pre-Booming Requirements for Fuel Transfers
7. Lighting of Lease Structures to Minimize Effects to Spectacled and Steller's Eider

[2] The NEPA review process for each agency involves:
- EIS/EA and ESA review
- Section 7 Biological Opinion and ITS for ESA species
- EFH assessment

[3] SHS includes:
- Clearance of potential hazards for placement of anchors
- Includes clearance of archaeological features

ACRONYMS

4MP	Marine Mammal Monitoring and Mitigation Plan
A&A	Ancillary Authorization
ADEC	Alaska Department of Environmental Conservation
ADNR	Alaska Department of Natural Resources
AEWC	Alaska Eskimo Whaling Commission
APD	Application for Permit to Drill
APDES	Alaska Pollutant Discharge Elimination System
BLM	Bureau of Land Management
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
CAA	Conflict Avoidance Agreement
COCP	Critical Operations and Curtailment Plan
CWA	Clean Water Act
DIMP	Drilling Incident Management Plan
DOCD	Development Operation Coordination Document
EA	Environmental Assessment
EFH	Essential Fish Habitat
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EP	Exploration Plan
EPA	Environmental Protection Agency
ESA	Endangered Species Act
G&G	Geology & Geophysics
IHA	Incidental Harassment Authorization
ITS	Incidental Take Statement
JPO-SPCO	Joint Pipeline Office-State Pipeline Coordinator's Office
LOA	Letter of Authorization
LUP	Land Use Permit
MMPA	Marine Mammal Protection Act
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NSB	North Slope Borough
NWAB	Northwest Arctic Borough
NTL	Notice to Lessees
NWP	Nationwide Permit
OCSLA	Outer Continental Shelf Lands Act
OSRP	Oil Spill Response Plan
POC	Plan of Cooperation
ROW	Right of Way
SHS	Shallow Hazard Survey
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USFWS	United States Fish & Wildlife Service
WCD	Worst Case Discharge

Majority of requirements included, list may not be exhaustive

Figure 4-2. *Alaska OCS Oil and Gas Project Exploration and Development Requirements*

Energy Board) use centralized regulatory agencies for overseeing oil and gas activities.

- Oil and gas activities in Canada function under a single primary piece of legislation, the Canada Oil and Gas Operations Act, which provides significant clarity and defined timelines for permit applicants.
- The state of Alaska also uses a centralized permitting agency (Office of Project Management and Permitting, within the Department of Natural Resources) as a single point of contact to navigate permitting requirements of other state of Alaska agencies.

Reinforcing the conclusions of the 2011 NPC report, a 2013 report to the president found that:

> A fundamental goal for federal agencies is to improve interagency coordination on all aspects of science, management, stewardship, response, and permitting in the U.S. Arctic. *Whole-of-government* solutions should be pursued to eliminate redundancies and promote efficient operations.[1]

Recommendations

With regard to broad policy coordination and in light of the executive order issued in January 2015 on "Enhancing Coordination of National Efforts in the Arctic," which established the Arctic Executive Steering Committee, and with regards to regulatory systems and processes the study recommends the following:

- The Arctic Executive Steering Committee should:
  - Reaffirm U.S. commitment to prudent Arctic oil and gas development and U.S. leadership in the region
  - Assess alignment across federal agencies in advancing prudent Arctic oil and gas development
  - Request DOE and the Department of Commerce to partner to inform U.S. policymakers across federal departments and agencies about the economic, energy, and national security benefits of prudent Arctic oil and gas development, consistent with the DOE's mandate and the Department of Commerce's recently announced Arctic affinity group
  - Clarify the process by which it will collaborate with the state of Alaska, Alaska Native tribal governments, and other stakeholders.
- The Arctic Executive Steering Committee as part of its mandated gap analysis should:
  - Request regulators to compile a comprehensive and integrated inventory of regulatory requirements for offshore Arctic oil and gas exploration and development
  - Recognizing the significant progress by the IAWG on coordination of permitting in Alaska, the Arctic Executive Steering Committee should, as part of its gap analysis, review lessons learned for application to broader coordination of opportunities and identify areas for improvement
  - Recalibrate the existing IAWG to refine its mission and enhance its capabilities to coordinate Arctic activities and permitting
  - Review the effectiveness of DOE participation in the working group.
- The Department of Energy should designate a senior advisor to support its representative on the Arctic Executive Steering Committee and be a focal point for Arctic policy, including:
  - Producing a department-wide Arctic strategy which clarifies its implementation of the National Strategy for the Arctic Region
  - Advancing prudent Arctic oil and gas development
  - Coordinating with the U.S. Arctic Council Chairman
  - Coordinating the department's Arctic science and technology, integrated analysis, and research agenda and effecting full coordination and engagement of the National Laboratories.
- The Department of Energy should engage Alaska institutions including the state of Alaska in the planning and conduct of its Arctic initiatives and consider public-private partnerships and data sharing platforms similar to the Alaska Ocean Observing System.
- Under the Government Performance and Results Act, the IAWG, with the participation of all member agencies, could sponsor a review to identify duplication and conflict among existing federal and state jurisdictions.

- For the longer term, pursue increasing interagency cooperation on all Arctic permitting activities covering the oil and gas sector and related activities.
- Implement effective mechanisms for funding enhanced regulatory capacity and capability, including putting a higher priority on funding regulatory capacity versus other objectives, and extending existing authorizations for relevant government agencies to access third-party funding.

Adaptive Regulatory Frameworks Can Allow for the Adoption of Improved Technology and Operating Practices

There is no common set of standards or regulatory philosophies that is applied across the circumpolar Arctic. U.S. federal regulation of offshore exploration drilling has historically adopted a predominantly prescriptive approach under which specific operating practices and technologies are explicitly allowed or disallowed in the body of regulation. An example relevant to Arctic operations is that allowed oil spill responses in regulation only include mechanical recovery, when more effective solutions are available and can be enhanced further with technology development. This regulatory approach has been built up over several decades of operating and regulatory experience, primarily in the Gulf of Mexico and Alaska. However, this approach poses a challenge to both operators and regulators since it removes incentives to develop and deploy new and improved technologies. This imposes constraints on the regulatory system's ability to adapt to new, fit-for-purpose technologies and operating practices as they emerge, in spite of the benefits that they may provide. This prescriptive approach is particularly disadvantageous in the Arctic where operating conditions, in terms of ice type and abundance, tides and currents, proximity to support assets, etc., can differ from location to location. One size fits all prescription can result in suboptimal regulatory solutions for any particular operating location.

The oil and gas industry has a long track record of developing innovative technology for all aspects of its operations—not only exploration drilling and development systems, but also safety and environmental protection. It is in the interests of all stakeholders for such technologies and practices to be introduced where appropriate and feasible. However, a prescriptive regulatory approach can act as a serious barrier to new innovation. The issue was highlighted in the NPC's 2011 *Prudent Development* report, which recommended moving to a more balanced regulatory system with both prescriptive and performance-based elements.

A performance-based regulatory approach specifies the outcomes to be achieved with regard to any particular aspect of oil and gas operations. This puts the burden on operators to demonstrate that the technologies and operating practices included in their exploration or development plans as submitted to the regulatory authorities achieve or surpass the specified regulatory objective. This approach is therefore accommodative to new technologies and a better fit to deal with the challenges and operating practices for the particular locations where drilling operations are proposed.

In the course of this study, the technology working groups identified a number of areas where current regulations disallow or restrict currently available alternative solutions and would thus not give incentives for ongoing improvement or wide dissemination of new technologies. The following are the principal examples identified, most relevant to Arctic operations:

- Federal Aviation Administration restrictions on unmanned aerial vehicles inhibit the ability to undertake more extensive and safer aerial ice surveys. The same regulations pertain to open water and ice cover conditions when permitting seismic acquisition activities.
- Regulations are not currently written to accommodate moored vessels capable of station-keeping in ice conditions.
- Regulatory or permit requirements for same season relief well capability do not recognize more effective and lower environmental impact capping and containment solutions.
- Well control regulations do not account for post-Macondo standards in capping and containment.
- Regulations covering oil spill response do not take into account the capacity of the platform to store oil resulting from a loss of well control when calculating worst case discharge outcomes and thus response requirements.

- Regulations do not allow advanced technology deployment for pipelines such as advanced integrity inspection, leak detection, and variable geometry of the pipeline to reduce the potential for gravity-induced loss of oil to the ocean in the event of a leak.
- Lease stipulations currently unilaterally favor pipeline offtake only.
- Allowed oil spill responses in regulation only include mechanical recovery, when more effective solutions are available and can be enhanced further with technology development.

In this regard, the United States is unusual among Arctic nations in having a predominantly prescriptive approach to regulation.[2] Other jurisdictions tend to have a regulatory approach in which adaptive, performance-based regulations are predominant or which incorporate a hybrid approach encompassing both systems, depending on the aspect of operations to be regulated. For example:

- The United Kingdom has a performance-based approach for the North Sea. Operators must demonstrate that they minimize hazards and risks as much as reasonably practical, by presenting performance data to support applications to drill and produce against goal setting regulations.
- Norway has a performance-based approach with guidelines and standards and is widely seen as a model for implementing effective performance-based standards. Norway's regulatory structures have differentiated responsibility for the safety and environmental aspects of operations (the Petroleum Safety Authority [PSA]) from the responsibility for overseeing hydrocarbon development and production (the Norwegian Petroleum Department). Both agencies have a strong collaborative relationship and very open communication with operators regarding appropriate standards and technological solutions. The PSAs regulatory vision has been articulated as follows:
  - The regulatory framework shall be flexible in terms of technological, operational, and organizational development in the petroleum industry.
  - The regulations shall be developed in dialogue and cooperation with the employer and employee organizations in the petroleum activities (tripartite collaboration).[3]

  A recent report from the Pembina Institute has also highlighted Norway's move toward a more adaptive, performance-based regulatory approach.

  > As Norway employs a performance-based regulatory approach, its regulations contain very few mandatory technical requirements. Instead, they establish requirements to manage operations and build facilities to meet certain objectives, often performance requirements for identifying and reducing risk, along with requirements for management systems to ensure performance attainment. The PSA publishes and regularly updates a non-legally-binding guideline for each provision of each of the sets of regulations. In this way, the PSA recommends practices for fulfilling the regulation ("should"), then offers alternatives ("may") for offshore installations to meet the requirements where they can show that the method is equally effective in attaining the same objective. Regularly, these recommended practices and suggested alternatives refer to industry standards.[4]

- Canada has a strong central agency, the National Energy Board. While geophysical operations are regulated with a prescriptive approach, most other activities are regulated with performance standards, making the system a hybrid blend of performance-based and prescriptive regulation.
- Greenland, like Norway and the U.K., uses a performance-based approach in which operators need to demonstrate that they are adopting international best practices for the Arctic operating environment.

The contrast between performance-based (adaptive) and prescriptive regulatory philosophies, and their application across various Arctic jurisdictions, has been the subject of commentary from the Arctic Council. The Arctic Council has defined a prescriptive approach as one in which standards are adopted as explicit regulatory requirements. A regulatory body then evaluates and inspects operations in accordance with these set standards.[5]

In contrast, performance-based regulations are designed to place more responsibility on and encourage innovation by the operators. While the regulator remains responsible for setting quantifiable goals and evaluating compliance, the performance-based approach leaves the means of reaching those goals up to the operators.[6]

There are an increasing number of regulatory systems that are moving toward performance-based standards. However, as exemplified above, the two approaches are not mutually exclusive. As the Arctic Council notes in its *Arctic Offshore Oil and Gas Guidelines,* a combination of prescriptive and performance-based standards is a viable regulatory option that allows some flexibility.[7] This hybrid approach is often used when regulatory systems traditionally using prescriptive standards are being revised or adapted to performance-based standards.

A combination of regulatory approaches to balance the need for incentivizing innovation while prescribing minimum requirements in certain key areas could be a viable solution. In support of this statement, the Arctic Council's Emergency Prevention, Preparedness and Response Working Group concluded that: "A combination of prescriptive and functional (goal-based) requirements was identified as the optimum solution,"[8] and the Council's Oil and Gas Guidelines are also an example of a hybrid of performance standards and a prescriptive approach.

In conclusion, Arctic operating environments are subject to substantial variation on both a local and regional level. Performance-based regulation allows innovation and learning in operating practices, environmental performance, safety, and cost effectiveness of operations, incentivizing the development and deployment of technology advances. Additionally, successfully implemented performance-based standards are consistent with stringent and effective regulation, as demonstrated in other Arctic jurisdictions, and can be set to the level of assurance that meets the critical regulatory objectives.

Similar findings have been recorded by other relevant bodies in the recent past, indicating that performance-based regulation is worthy of serious consideration:

- "The Department of the Interior should develop a proactive, risk-based performance approach specific to individual facilities, operations and environments, similar to the 'safety case' approach in the North Sea." *Deepwater Horizon: The Gulf Oil Disaster and the Future of Offshore Drilling,* National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, Report to the President, 2011, p. 252.
- "There should be a clear process for approval of exploration plans, oil spill response plans, and applications for permits to drill based on performance standards alone." Listening Session, Bureau of Ocean Energy Management and Bureau of Safety and Environmental Enforcement, Vol. I., Anchorage, Alaska, June 6, 2013.

Lastly, current Bureau of Safety and Environmental Enforcement (BSEE) regulations provide for the authorization of equivalent solutions to meet regulations in Title 30 CFR 250.141 of the BSEE Mineral Resources Enforcement Code as shown in the text box on Title 30 CFR 250.141. Thus there is an established precedent in the regulation for examining the expansion of adaptive, performance-based regulatory solutions more widely, whenever the regulatory objective can be achieved or surpassed using an alternative approach or technology.

Recommendations

- Policies and regulations should encourage innovation by providing for incorporation of technological advancements.
  - Authority already exists to consider industry proposals that provide for equivalent or better levels of safety and environmental protection, such as that already established in 30 CFR 250.141; use of that authority should be encouraged. For example, BSEE could develop an Arctic Operating Plan patterned after the existing deepwater operating plan approach in CFR 250.286 as a basis for encouraging and driving innovation.
  - BSEE should continue to review existing and new regulations to identify candidate areas for implementation of performance-based regulation, considering lessons from other jurisdictions.
    - Such a review could be completed on a timetable allowing implementation of new regulatory approaches prior to the next round of Alaska Arctic OCS leases, encouraging operators that

Title 30 CFR 250.141 as a Mechanism for Adaptive Regulation

There are existing provisions in offshore oil and gas regulation that can be used to allow alternative technologies, methods, or operating practices to achieve a result other than those specified prescriptively in the existing regulation. These provisions can be used to introduce more advanced technologies or operating practices as they emerge within the context of existing projects or new project proposals.

Title 30 of the Code of Federal Regulations deals with mineral resources. Chapter 2 of CFR 250.141 contains the regulations under the jurisdiction of the Bureau of Safety and Environmental Enforcement (BSEE) of the Department of the Interior. Sub Chapter B deals with the Offshore and Part 250 contains regulations dealing with oil, gas, and sulphur operations in the Outer Continental Shelf. It is in this section that the relevant authority for BSEE to approve alternative methods or technologies to those prescribed by existing regulation is defined. The text of the provision follows here:

"§ 250.141 May I ever use alternate procedures or equipment?

You may use alternate procedures or equipment after receiving approval as described in this section.

(a) Any alternate procedures or equipment that you propose to use must provide a level of safety and environmental protection that equals or surpasses current BSEE requirements.

(b) You must receive the District Manager's or Regional Supervisor's written approval before you can use alternate procedures or equipment.

(c) To receive approval, you must either submit information or give an oral presentation to the appropriate Regional Supervisor. Your presentation must describe the site-specific application(s), performance characteristics, and safety features of the proposed procedure or equipment."

The onus for demonstrating performance of an alternative technology or operating practice that matches or exceeds that prescribed in current regulation rests on the operator or project proponent and must be demonstrated and authorized on a case-by-case basis by the District Manager or Regional Supervisor of the area where the oil and gas project is located. Therefore, while this provision does provide an avenue for deployment of improved and innovative technology or practices, it may not facilitate rapid and general deployment of such advancements, given the case-by-case nature of the review and approval process and the need to work through local BSEE offices, which may result in divergences of outcome.

participate in the next lease sales to prioritize technological advances.

- As part of the review process, define Arctic-appropriate regulatory objectives for operations and environmental performance, incorporating, wherever feasible, lessons from other Arctic countries on the definition of performance-based regulatory approaches covering specific areas.

– Staff development should be pursued through ongoing recruitment and training of regulatory staff in Arctic-specific operations, and regulatory requirements should be pursued within regulatory agencies.

The Application of Available Technology Has the Potential to Safely Extend the Drilling Season

The Arctic is a different operating environment that requires some unique technologies, significant financial resources, and a long time to explore and develop. A major factor in the time needed for successful exploration and development is the impact of the short offshore drilling season length given activities are currently restricted to the open water season.[a] Seismic, data gathering, and drilling activities can take several seasons, and the number of exploration or appraisal wells that can be drilled per drilling rig in any given season is relatively low, thus impacting both the cost and the ability to decide if a resource is economically viable to warrant moving to the development phase. If activities could be safely extended into the shoulder season,[b] the additional time available could significantly reduce the total time required to explore, appraise, and develop a given resource.

Currently, the length of the offshore drilling season for locations beyond landfast ice in the U.S. Arctic is limited by ice conditions and regulation and recent permit restrictions that only allow drilling activities to occur during the open water season. The open water season is typically 3 to 4 months and can be even shorter in practice if ice incursions occur. This time is further shortened by recent permit restrictions and regulatory expectations to be able to drill a same season relief well (SSRW)[c] as the primary method to secure the well in the unlikely event of a loss of well control. A SSRW in this area can take more than a month to drill. Additionally, the season length can be further shortened by voluntary agreements between individual operators and subsistence users that, for example, limit activities during the open water whaling season in certain areas of the Beaufort Sea. Combining these factors, the practical drilling season in parts of the U.S. Arctic could be as little as 40 to 60 days.

Considering the short amount of time an operator has available to drill in a given season and the long time that it can take to determine the economic viability of a lease holding, addressing the length of the season is a key priority to enable prudent development. Of all the aspects that must be addressed, prevention of major oil spills and effective response to a spill is of paramount concern to all stakeholders. Concerns regarding industry's capacity and capability to prevent spills and to responsibly and promptly deal with spills in Arctic waters, especially in the presence of ice, are in the forefront of any discussion about offshore drilling plans in the U.S. Arctic. Addressing these concerns will be critical to acceptance of extended season drilling operations.

Allowing safe and efficient exploration requires four key aspects to be addressed:

- Drilling, logistical support, and emergency response system capability in ice
- Source control and well secure techniques
- Oil spill response in ice
- A regulatory framework to ensure technology innovation is advanced, as discussed in the previous section.

The technology exists to drill during the open water season and into the early ice season also called the shoulder season. As discussed in Chapters 1, 5, and 6 of this report, ice-strengthened drilling rigs and ice management techniques have been field-proven in shoulder season ice environments, including during the Beaufort and Chukchi Sea exploration drilling programs of the 1980s. When drilling in ice, ice management is a key method used to ensure the rig safely stays on location and in the unlikely event of an oil spill to support the response. This involves ongoing forecasting of ice movements over time, detection of thicker or stronger ice that could push the rig off location, and, in the case of active ice management, breaking ice to ensure the rig can withstand any ice impact. Furthermore, controls and barriers are used to ensure well integrity, and technology and procedures are available to cease operations if conditions become unsafe. Additionally, emergency and oil spill response equipment and techniques are available and have been demonstrated to safely evacuate personnel,

a The season start date is set by U.S. Fish and Wildlife Service Incidental Harassment regulations for certain marine mammals. The season end date is set by BOEM based on NOAA assessment of the likely ice freeze date and by BOEM interpretation of their regulatory authority to require a same season relief well and the appropriate time needed to execute the relief well; a same season relief well is not specifically required by regulations. This interpretation is based on 30 CFR 550.213 (g) Blowout scenario. "A scenario for the potential blowout of the proposed well in your EP that you expect will have the highest volume of liquid hydrocarbons. Include the estimated flow rate, total volume, and maximum duration of the potential blowout. Also, discuss the potential for the well to bridge over, the likelihood for surface intervention to stop the blowout, the availability of a rig to drill a relief well, and rig package constraints. Estimate the time it would take to drill a relief well." It is also based on 30 CFR 250.400 through 490, which requires that any drilling unit must be fit for purpose for its environment (i.e., the Arctic), which includes an assumption that a relief well drilling unit would be needed to meet the fit for purpose requirements.

b The shoulder season is defined as the period between the early season break-up of ice and late season freeze-up. This is effectively past October 31.

c A relief well is a separate well drilled to intercept and permanently stop the potential for flow ("kill") from the blown-out well. A same season relief well is a relief well that is drilled in the same drilling season as the well the relief well is designed to "kill."

secure the well, and respond to an oil spill in ice in the unlikely event of a loss of well control that results in oil spilled to the environment. Season extension would be based on the capability of the entire drilling, logistical support, and emergency response system to operate safely.

Fundamentally, drilling practices to protect against a loss of well control incident are the same for Arctic wells as they are elsewhere in the world. While specific Arctic challenges such as ice conditions, cold temperatures, and remoteness can affect equipment selection and logistics, the design and construction of a well and the controls and barriers used to prevent incidents are common to worldwide best practices. These barriers and controls include regulated and industry standard well designs including casing, cement, and mud to contain formation pressures. Additionally, continuous monitoring of critical parameters during drilling is also performed. Furthermore, barriers such as blowout preventers, which can rapidly shear well pipe and close the well in the case of a loss of well control event, are also used. In the unlikely event that these methods fail, recent technological advances in additional well secure techniques such as capping stacks and subsea isolation devices have been shown to secure a well safely, more efficiently, and with less oil spilled than is possible with a relief well.

Technological advances, as discussed in Chapter 8, that could be used as alternatives to a SSRW include capping stacks (the device ultimately used to stop the flow of oil from the Macondo well) and subsea isolation devices. The use of these technologies can significantly reduce the amount of spilled hydrocarbons, compared to a relief well as they can be implemented in a matter of hours, days, or weeks upon the loss of well control, compared to a relief well, which can take more than a month. Extending the drilling season would be based on the capability of these systems to operate safely and reliably in an Arctic environment. Furthermore, post-Macondo, the DOI has issued NTL 2010-10,[d] which requires that wells must be designed to be capped, and if not, contained. Additionally, if these technologies can be used to safely extend the drilling season length the resulting increase in cost effectiveness provides greater incentive for companies to invest as the longer drilling season provides a greater likelihood of completing the necessary exploration and appraisal program required to advance the project to the development phase.

In the unlikely event of a loss of well control resulting in an oil spill, there are many field demonstrated techniques that are effective in ice. As discussed

Useful Definitions for Subsequent Text Box Examples

Drilling Start Date: The date when the drilling system can be safely mobilized to site. Considerations include the capability of the drilling system to safely transit through and operate in ice, as well as permit restrictions such as those used to protect wildlife during migration.

Drilling End Date: The drilling season end date less the time required to allow the chosen well secure technique to be safely implemented. This is applicable to drilling in zones that may have hydrocarbons only.

Well Secure Technique: This is the technique to be used to stop the flow of hydrocarbons in the unlikely event of a loss of well control incident. Techniques can include relief wells, capping stacks, and subsea isolation devices as discussed in Chapter 8.

Well Secure Duration: The time required to safely implement the chosen well secure technique.

Freeze-Up Date: The date when regulators estimate freeze-up to occur at the lease location in question. The shoulder season begins after this date.

Drilling Season End Date: The date all drilling or well secure activity must cease and all equipment demobilized from the drilling location. This date is set as the assumed freeze-up date, which often occurs around November 1 in areas of the U.S. Arctic.

d A regulation introduced by BSEE is the Notice to Lessees, 2010-NTL 10, dated November 8, 2010. Titled, "Statement of Compliance with Applicable Regulations and Evaluation of Information Demonstrating Adequate Spill Response and Well Containment Resources," this NTL gives lessees operating on the U.S. Outer Continental Shelf (OCS) additional requirements that must be fulfilled before granting a Permit to Drill/Revised Permit to Drill/Permit to Modify (APD/RPD/APM). Although not explicitly stated in NTL 10, the BSEE requires the operator to demonstrate in the APD that the well design is adequate to contain an uncontrolled flow.

in Chapter 8, industry and government sponsored research show a variety of oil spill response methods, including mechanical recovery, in-situ burning, use of dispersants, and remote sensing to detect oil in and under ice, that are all effective in ice, as demonstrated with field trials in Canada and Norway.

The useful definitions text box provides several key definitions useful for understanding the subsequent examples. The text box containing the current season length example shows how the drilling season length could be determined using the current approach applied to the U.S. Arctic.

Example: Current Season Length Determination Process

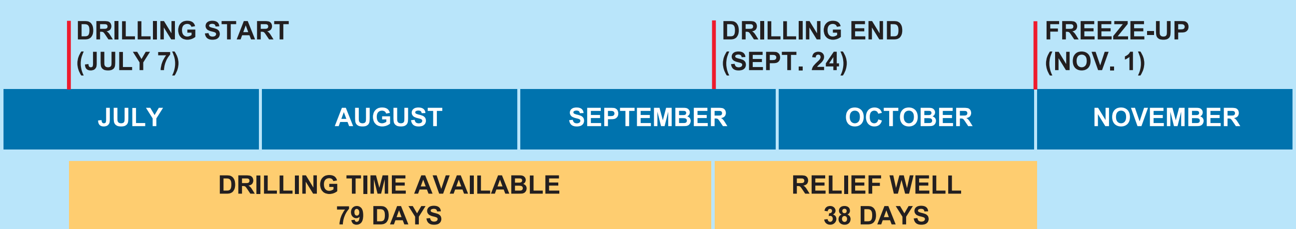
Currently, for example, in the western area of the U.S. Chukchi Sea, the earliest drilling start date is determined to be July 7 based on an a 7-day estimated mobilization time to the Chukchi Sea from the Bering Strait and considering recent permitting restrictions allowing access to the Bering Strait no earlier than July 1.* The drilling end dates are currently based on the number of days required to drill a same season relief well prior to the assumed freeze-up date of November 1. Neither the capability of the drilling system to operate safely in ice based on historical precedents, nor the use of alternative well secure techniques are considered in setting these dates. The timeline below depicts the current system timelines assuming a relief well duration of 38 days (the typical time to drill a relief well to a shallow target using the current approach applied in the U.S. Arctic).

There are several shortcomings of this prescriptive approach:

- Drilling a relief well takes significantly longer than other available well secure technologies. Thus, using a relief well is more likely to result in a greater volume of spilled oil when compared to alternative technologies.
- Designating a start and end date uniformly rather than basing them on the actual drilling system capability is not an efficient use of the significant capital investment in advanced systems.
- The 79-day drilling season length in the example above is barely sufficient to complete and evaluate a single well for many exploration prospects. This can result in multiple seasons being required to drill a single well, adding cost and time in an already challenging, costly, and remote operating environment. When considering this in the context of the relatively short 10-year lease term, as discussed in the section on improved lease duration and terms, the economic disincentive for companies to invest can be significant.

Basing the drilling season length on the actual drilling system capability and on currently available advanced well secure techniques can achieve the same goals of safety and environmental sustainability and stewardship to be achieved without the shortcomings of the current approach. Doing so would require demonstrating to regulators and stakeholders that the drilling system to be used is indeed capable of safe, reliable operation throughout a longer drilling season, and that advanced well secure techniques are safe, effective, and reliable. Making such a change would facilitate more cost-effective Arctic exploration without compromising environmental and safety standards.

* The earliest transit through the Bering Strait is based on the U. S. Fish and Wildlife Service's (USFWS) Intentional Take regulations. The USFWS has determined that transit through the Bering Strait will be assessed on a case-by-case basis or otherwise limited by regulations to July 1 passage.



Example of Current Season Length Determination Process

The examples shown in the text box on drilling until freeze-up and the text box on drilling into the shoulder season highlight two options to extending the drilling season.

1. Allow the use of alternative well secure techniques in place of a same season relief well and maintain the requirement that drilling end at freeze-up
2. Allow the use of alternative well secure techniques in place of a same season relief well and extend the drilling season into the shoulder season. In the Oil Spill Response Plan submitted to BSEE, the operator would include how they would respond to a spill in the shoulder season, including the response equipment, strategies, and ice management capabilities.

The key assumptions used in both of these examples are as follows:

- An assumed freeze-up date of November 1st—actual freeze-up dates may vary.
- Last drilling date in shoulder season of December 15th—with suitable ice class drilling system and based on historical capability—the actual date may vary depending on the capability of drilling equipment, marine support, and emergency support services.
- As indicated in Chapter 8, it is understood that, depending on a number of factors, either a well capping system or a subsea isolation device may be used to stop the flow and safely secure the well.
  - Well capping duration—14 days (based on an in-field well capping system).
  - Subsea isolation device duration—0 days (essentially instantaneous).
  - The well secure duration values chosen in this example are indicative and, as such, do not necessarily reflect those that may be submitted by an individual operator in their drilling applications.
  - The bar charts contained in the examples will thus indicate a well secure range from 0 to 14 days.

Example: Use Alternative Well Secure Techniques and Drilling in Open Water until Freeze-Up

The timeline below shows that by considering alternative well secure techniques, the drilling season length can be prudently increased.

- Drilling season length increased by approximately 30 to 50 % from 79 days to 103 to 117 days depending on the choice of alternative well secure system.
- Last drilling date extended from September 24 until between October 17 and November 1, depending on the choice of alternative well secure system.
- A significant reduction in amount of spilled oil prior to the flow being stopped and the well safely secured in the event of a spill.

This increase in the drilling season length could significantly increase the likelihood of completing the drilling and appraisal of an exploration well within a single operating season. This has the potential to significantly reduce exploration drilling costs and, in turn, increase the economic attractiveness of these otherwise very costly projects.

Example Timeline Assuming a Capping Stack or Subsea Isolation Device Instead of a Same Season Relief Well

Example: Use Alternative Well Secure Techniques and Extended Season Drilling into the Shoulder Season

The timeline below shows that by considering alternative well secure techniques and using the capability of the ice class drilling system, the drilling season length can be further increased.

- Drilling season length increased by approximately 85 to 105 % from the current 79 days to 147 to 161 days, depending on the choice of alternative well secure system.
- Last drilling date extended from September 24 till between December 1 and December 15, depending on the choice of alternative well secure system and capability of the ice class drilling system.
- A significant reduction in amount of spilled oil prior to the flow being stopped and the well safely secured in the event of an oil spill.

This increase in the drilling season length could significantly increase the likelihood of the ability to complete a multi-well exploration program in a given season. A detailed appraisal program could also be completed with a higher degree of confidence. The effect of essentially doubling the drilling season would result in substantial cost savings, which, in turn, would likely have a significant positive impact on project economics. The extension of the season in this manner is required to support the high capital costs associated with the investment in an ice class drilling system.

Extended Drilling Season into the Shoulder Season and Use of Alternate Well Secure Techniques

- The well secure operation will be a two-stage operation, namely:
  - Stage 1: Stop the flow and safely secure the well as quickly as possible in the same operating season in which the loss of well control event occurs.
  - Stage 2: With the well safely secured, the well intervention operations required to safely plug and abandon the well can be planned for the following season at which time a relief well may, or may not, be required.

In conclusion, a careful consideration of alternatives to the current prescriptive approach to the drilling season end date and the well secure option has the potential to safely extend the drilling season while significantly reducing the potential volume of spilled oil in the unlikely event of a loss of well control. In recognition that extending operations into ice requires careful and diligent consideration, the regulator could allow, through authority granted under Title 30 CFR 250.141, any agreed and demonstrated capability of the drilling system to be used in determining the start and end dates for drilling. This authority gives the regulator the option to accept available technologies that can be demonstrated to provide equal or superior environmental protection and safety (compared with the current system).

Recommendations

Oil Spill Prevention and Source Control

- Industry and regulators should work together with government agencies and other stakeholders to synthesize the current state of information and perform the analyses, investigations, and any necessary demonstrations to validate technologies for improved well control and containment. Canada is using an approach described in the text box entitled "Evaluating Same Season Relief Well Equivalency."

- The benefits and risks of advanced control and containment technologies should be assessed relative to the current practice of a same season relief well. Alternatives include capping stacks and subsea shut-in devices independent of the standard blowout preventer. These alternatives could prevent or significantly reduce the amount of spilled oil compared to a relief well, which could take a month or more to be effective. This assessment should consider the benefits and risks of leaving the well secured using these technologies over the winter season.

  DOE should work with industry and DOI to perform this assessment, engaging the National Laboratories, the National Academies, and other stakeholders as appropriate. Assessment techniques could include those used in the nuclear, aviation, and petrochemical industries, such as precursor analysis and quantitative risk assessment, where DOE already has expertise.

- Future regulation and permit requirements should be informed by the results of this analysis including required demonstrations and testing. DOI, DOE, and the National Laboratories should witness these demonstrations of improved well control and containment devices and include appropriate observers from the stakeholder community.

Oil Spill Response in Ice

- Regulators should continue to evaluate oil spill response technologies in Arctic conditions, considering past and ongoing research. Future regulations and oil spill response plans should consider this evaluation such that other technologies could be used as primary response options.

Drilling and Emergency Response Capabilities in Ice

- Industry and regulators should work together with other government agencies and stakeholders to synthesize the current and evolving state of knowledge and perform the analysis, investigations, and any necessary demonstrations to validate technologies and capabilities that could safely extend the useful drilling season length.
  - These technologies include recent advancements in source control and containment and improvements in oil spill response in ice discussed above.
  - The capabilities include the drilling rig, ice management vessels, and emergency and oil spill response capability.

Improved Lease Duration and Terms Will Facilitate Prudent Development in a Frontier Location

The NPC's 2011 *Prudent Development* report recognized the difficulty of frontier exploration and production in the 10-year lease term, recommending in the Executive Summary that the government should "Allow the length of leases to correspond to the long development lead times necessary to allow for appropriate incentives for private-sector investments in exploration and prudent development."[9] In addition to lease duration, more frequent lease sales in the Arctic can also advance prudent development by ensuring predictable access to new acreage. We also address in this section the Outer Continental Shelf Lands Act (OCSLA) regulations, which require an operator who has ceased operating on a lease to resume operations within 180 days of lease expiry if they want to retain the lease.

The OCSLA limits the primary term of any OCS lease to a maximum of 10 years. Similarly, leases on federal lands in the National Petroleum Reserve in Alaska (NPR-A) are also limited to a 10-year primary term. If oil or gas is discovered, but cannot be shown to be commercially viable for development, the lease must be relinquished, leaving the operator with no return on the investment in exploration. A recent Wilson Center study concluded:

> The length of lease terms in the Arctic has had the greatest influence on North American Arctic resource development. Given the extremely high costs of drilling in remote, icy Arctic conditions, and the severe limitations of the Arctic drilling season (drilling on average can be conducted only during a 3- to 4-month window in the summer), longer-term leases are one of the few incentives governments can offer to companies to justify the immense up-front exploration and drilling capital expenditure commitments. The 10-year lease term in effect in the Alaskan Arctic is inadequate to support

Evaluating Same Season Relief Well Equivalency

The Canadian Experience

National Energy Board (NEB) Same Season Relief Well Hearing

In 2010, the Canadian National Energy Board (NEB), the government body responsible for regulating offshore drilling in the Canadian Arctic, initiated a public process to review the long-standing Same Season Relief Well Policy and provide operators an opportunity to propose alternative technology approaches that would meet or exceed the intended outcome of the Policy. Following the Macondo incident, the NEB cancelled the Same Season Relief Well Hearing process and replaced it with a more broadly scoped review of all components of drilling activities in the Canadian Arctic Offshore. This process was initiated as the NEB Arctic Offshore Drilling Review.

NEB Arctic Offshore Drilling Review (AODR)

The objective was to provide a comprehensive review of Arctic offshore drilling preparedness including:

- Drilling safely while protecting the environment
- Responding effectively when things go wrong
- Learnings from past incidents
- Filing requirements for applicants seeking an authorization to drill.

The NEB conducted the review as a fully public process. All interested parties within Canada were given an opportunity to provide input into the review design and process. The NEB released a comprehensive written request for information on the above topic areas, and all written submissions were made publicly accessible via the NEB website. After the written review period, a week-long workshop was conducted to discuss the content of the Review.

The NEB held community meetings across Yukon, Northwest Territories and Nunavut to hear residents' views. All interested parties within Canada were invited to provide written comments. Inuvik workshop attendance included more than 200 representatives from government, communities, industry, academia, ENGOs, the general public, and government representatives from Alaska and Greenland.

The NEB released two final reports following the review:

- *Review of Offshore Drilling in the Canadian Arctic: Preparing for the Future*
- *Filing Requirements for Offshore Drilling in the Canadian Arctic.*

The Filing Requirements outlined the necessary components a proponent must provide in a submission for a drilling program. The NEB reaffirmed the Same Season Relief Well Policy, but stated they would consider proposals that would meet or exceed the intended outcome of the Policy on a case-by-case basis.

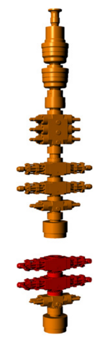
NEB Advance Ruling on or Same Season Relief Well Policy

The AODR proceedings clearly demonstrated the benefit of applying the most current proven technology to planned drilling programs. Two separate industry applications were initiated requesting an advance ruling on proposed alternative methods for a same season relief well.

The National Energy Board has yet to determine the final format of the process to provide the advance rulings. The NEB is expected to continue its commitment to public involvement in the process. As of March 2015, the review process is underway.

Case Study: Evaluating Same Season Relief Well Equivalency Related Technology Development

The Chevron/Cameron Alternative Well Kill System (AWKS)



- In 2008, Chevron identified the need for and initiated an R&D project that would meet or exceed the required Same Season Relief Well Policy in the Canadian Arctic offshore.
- Technology selection criteria included consideration of a tangible technology that could be demonstrated to, and understood by, local stakeholders who were involved directly in the project team.
- Project initiated in 2008 as a technology joint venture between Chevron and Cameron, with the goal of developing a step change in best available BOP technology.
- Developed the concept of a fully independent safety package including two shear rams capable of simultaneously shearing and sealing heavier wall, larger diameter tubulars and casing than was currently possible.
- A proof of concept testing video distributed to local stakeholders and regulators with the intent of educating interested parties on the project scope and objectives.
- Consultation was conducted with local stakeholders on equipment testing criteria.
- Held numerous engagement and education sessions with local community stakeholders, including equipment demonstrations.
- Joint representation with local stakeholders at major conferences discussing both industry and community perspectives on the SSRW Equivalency issue.
- Successfully completed internal testing of AWKS in May 2014, thereby making AWKS ready for commercial deployment.

ongoing exploration and evaluation of oil and gas potential. Given the infrequency of lease sales and the lengthy permitting processes that involve multiple federal and state-level government agencies, the 10-year timeline is hardly long enough to accommodate a preliminary drilling program; it also poses serious risks to cost recovery prospects.[10]

Lease Duration

Longer leases in the Arctic could increase and improve opportunities to prudently develop the resource there, improving U.S. economic growth and energy security. The 2011 NPC study found that "current and future development of U.S. and Canadian oil can translate into energy security benefits through reducing oil imports. Other potential benefits include improved balance of trade, jobs, and economic multiplier effects from domestic drilling, production, and delivery."[11] Longer lease terms would not necessarily result in being onsite longer. It will take the same number of wells to explore and appraise a prospect, and it is clearly to the benefit of the operator to conduct exploration and appraisal expeditiously and prudently to commence development of the resource. To ensure environmental, health, and safety protections, the OCSLA regulations provides the Department of Interior with authority to add any appropriate stipulations in the leases in response to concerns raised by coastal states, federal agencies, tribes, and other stakeholders, and longer lease terms would not change this.

To provide some context for the need for longer lease duration in the Arctic, consider a comparison with the U.S. Gulf of Mexico (GOM). In the Gulf and the rest of the United States, OCS lessees can explore 12 months of the year. As described in the previous section, in the Alaska OCS, there is only a 3 to 4 month open water operating season, and it can be even shorter in practice if ice incursions occur. This time has been further shortened by a permit stipulation to allow for a same season relief well to secure a well in the unlikely event of a loss of well control. The season length can be further shortened by voluntary agreements between industry and subsistence users that, for example, limit activities during the open water whaling season in certain parts of the Beaufort Sea. Combining these factors, the practical exploration drilling season could be as little as 40 to 60 days. Onshore in NPR-A, a similar situation occurs where winter tundra travel is only open when there is 12 inches of ice overlain by 6 inches of snow. This often limits the available season from mid-December to late April. Considering the mobilization time that often involves building an ice road, as well as the Bureau of Land Management requirement to preserve enough time to drill a relief well, the effective exploration season is often no more than 90 days.

Exploration and appraisal (E&A) activity in the Alaska OCS is also different than in the GOM. Beyond the initial exploration well on a given prospect, an operator in Alaska will typically require more appraisal wells on a given prospect to establish commercial viability. This is in part because field sizes in Alaska are expected to be in the billions of barrels compared with smaller 300- to 500-million-barrel size fields in the GOM. Alaska also has less available seismic information, which leads to the need for more appraisal wells than is typically required in the GOM. The largest field in the GOM is an area approximately 10 to 12 square miles. There is extensive seismic coverage in the GOM that can be obtained year-round. So, operators can assess a field, determine the appropriate well locations, and move to exploration drilling within 1 to 2 years of lease assignment. The hydrocarbon density is typically high in the GOM because the reservoirs are usually vertically stacked. This size and type of prospect at most requires three to four appraisal wells to assess the scope and mitigate uncertainties before making a commerciality decision. Furthermore, fit for purpose rigs are also more available in the GOM allowing wells to be drilled simultaneously. Taking all of this into account, a full E&A program in the GOM can in general be completed in 4 to 6 years (depending on water depth and/or timing of the spud of the initial well).[e]

In the Alaska Arctic offshore, prospects are much larger in both field area and volumetric size. Volumes on the order of 1 to 2 billion barrels are possible and, for example, the Chukchi Burger prospect covers an area of 400 square miles. The reservoir formations are typically not densely stacked but instead spread across large areas. There is very little seismic data available in the Chukchi and it may take 2 to 3 years to acquire permits and then additional time to physically acquire the data given the short open water season. For example, it took three open water seasons to obtain seismic data for the Chukchi Burger prospect. Once seismic data are acquired, operators then need at least 1 year to undertake a technical evaluation of the data to determine the sequencing of appraisal wells up to an additional 2 years to obtain permits and conduct the required shallow hazards seismic surveys over the key well locations. An operator in the Arctic may not be able to move to drill until 4 years into the 10-year lease term and even after an initial discovery and appraisal, additional seismic data might still be required to further delineate a prospect.

In addition to the time required to plan and conduct exploration and appraisal activities, the inherent uncertainty in prospective frontier areas such as the Alaska OCS means that the subsurface knowledge gained from each drilled well has an even greater impact on future drilling decisions, whether on the immediate prospect or other prospects in the inventory. Therefore, exploration and appraisal activities must proceed serially—one after the other—because the results of the first well in each area will determine where the next well should be drilled. With a very short season, and as discussed in Chapter 2, it may take 2 years to drill one well. Given the very large geologic structures in the Alaska OCS, it is expected to take three to nine appraisal wells per prospect to mitigate uncertainties to the point where a large financial commitment to move to production is warranted. As an example of the total amount of time required, consider this: as described above, an operator in the Arctic may not be able to move to drill until 4 years into

e Noting that for some ultra-deepwater leases in the Gulf of Mexico with advanced technology requirements, a 10-year lease term could be insufficient due to application of new blowout preventer technology, new subsea facility approaches, etc.

the 10-year lease term. If completion of one well only requires a single drilling season, nine wells could take 9 years, which is more than the 6 years remaining on the lease. Moreover, if two seasons were required per well, drilling could take up to 18 years on one prospect. If the lease area holds multiple prospects, it is highly unlikely that an operator could execute assessments on more than one or possibly two prospects during a 10-year lease. Limited rig availability in the Alaska OCS now and for the foreseeable future also means that an operator cannot have many rigs drilling at the same time unlike in the GOM where rig availability is in generally not an issue. A complex regulatory environment that is open to litigation can further limit the time available for E&A and has resulted in the short 3 to 4 month drilling season being missed.

Other Arctic countries address the need for a longer lease term for frontier areas in various ways. In general, Canada, Norway, and Greenland all have more flexible terms. The U.S. lease system is development-based: to retain the lease an operator must be prepared to move into the development phase by the end of the 10-year lease term. In stark contrast, the Canadian and Greenland lease systems are exploration-based, allowing more time in the initial lease term for exploration. A recent press article indicates that Russian national oil company Rosneft may also seek to extend their Arctic lease duration.

"Canada offers lease terms that encourage greater [financial] risk-taking by energy companies willing to commit capital and resources to the Arctic."[12] The absence of a license time limit reflects the common reality that a discovery may be of a size and in a location that make it uneconomic to develop at the time. The benefit of this approach is that it provides "some reasonable assurance to the initial explorer that marginal oil and gas discoveries can be retained until they can be economically developed at some point in the future."[13]

The Parliament of Canada website describes the program:

> An exploration license (EL) is granted for a maximum of nine years and, can be extended if an EL holder has begun the drilling of a well, and is pursuing it diligently. The EL continues in force as long as may be necessary to determine the existence of a significant discovery based on the results of that well and provided that drilling is being pursued diligently.
>
> Once a discovery has been made, the operator is allowed to retain their licenses by receiving a Significant Discovery License (SDL). An SDL replaces the exploration license. The SDL allows the operator to hold the leases indefinitely until the discovered field is economically capable of being developed and produced.
>
> Once the developer has determined that the discovery can be commercially produced, a holder of an EL or a SDL is eligible to apply to the National Energy Board (NEB) for a declaration of commercial discovery. A "commercial discovery" is defined by the legislation as "a discovery of petroleum that has been demonstrated to contain petroleum resources that justify the investment of capital and effort to bring the discovery to production." In order to evaluate the application, the NEB must make a technical assessment of the size of the commercial discovery area based on well data, and oil and gas reservoir characteristics. The NEB must also assess whether the discovery justifies the capital investment that is required to bring the discovery to production.[14]

The Norwegian system also provides more time for exploration and development compared with the United States.[15] The regulatory agency, the Petroleum Safety Authority, explains:

> As a main rule, the production license is valid for a so-called initial period (exploration period) of four to six years. The licensees can apply to extend this period to up to ten years. During this time, a specific work commitment shall be completed in the form of seismic data acquisition and surveys and/or exploration drilling. When the initial period is over and the work commitment is completed, the licensees can apply for extension for a period as stipulated in the production license. In general, this period is up to 30 years. If exploration drilling does not prove oil or gas [or uneconomic in size to produce], the main rule is that the area shall be relinquished at the end of the initial period. For production

licenses awarded before 2004, the main rule is that the licensees in the production license can demand to retain up to one-half of the area of the production license for up to 30 years (if the work commitment is completed during the exploration period).[16]

Greenland, too, provides longer and more favorable lease terms. "Greenland permits operators to acquire much larger tracts of offshore blocks than the 3-square-mile blocks offered by the United States. Furthermore, in the Northeast Greenland offshore, operators can extend the initial license term to 16 years."[17]

A debate on Arctic lease terms has also recently begun in Russia. Current Russian law provides a maximum lease term of 10 years. The CEO of Rosneft, Igor Sechin, wrote a letter in 2014 to the Russian Ministry of Natural Resources requesting that the legislation be amended because it does not fully take into account the lengthy time frame for working in these areas.[18] Rosneft has requested that the ministry extend the lease duration to 15 years.

Table 4-1 summarizes the key differences in lease terms for each Arctic country. The difference between an exploration-based system and the U.S. development-based system is in the scope of work required to retain the lease. Exploration-based system regulations only require that a discovery is made within the lease term. For example, as described earlier, in Canada once a discovery has been made, the license can be converted into a Significant Discovery License, which allows the operator to hold the leases indefinitely until the prospect can be technically or cost effectively developed. In contrast, development-based lease system regulations requires that an exploration discovery and a field appraisal program are both executed to the stage of development planning (technical and commercial thresholds have been met) to retain the lease by the time it expires. As described in Chapter 2, this can be difficult to do in the Arctic. Depending on the shape of the geologic structures and what thresholds must be attained to reach commerciality, it may take a much more extensive drilling appraisal campaign for an operator to be ready to move to development.

In conclusion, a fixed 10-year lease term for Alaska OCS leases reduces the ability to identify, appraise, and develop economic volumes in the Arctic, hindering economic growth and energy security. There is no specific allowance made in the lease terms for the unique conditions in Alaska OCS or for time lost on a lease due to ice cover. Other Arctic countries have recognized that this is an issue and generally provide longer lease terms or other mechanisms to encourage investment in exploration.

Lease Sales

There are also other options to improve lease terms for Arctic exploration and development. Lease sales in the Alaskan Arctic OCS have been intermittent, limiting access to new lease blocks. DOI held a lease sale for the Chukchi Sea in February 2008 and has recently announced another sale in 2016—an 8-year gap. Four Chukchi and Beaufort Sea lease sales that were included in the 2007-2012 program were cancelled. In contrast, lease sales in the GOM are held every year. All of the exploration acreage currently leased in the Chukchi Sea will expire simultaneously with no assurance of future lease availability—a problem when exploration must take place serially. Conducting a

Country	Lease/License System	Typical Well Count to Retain Lease/License*	Lease/License Duration
Canada	Exploration Based	1 to 2	9 years
Greenland	Exploration Based	1 to 2	Up to 16 years
Norway	Exploration Based	1 to 2	Up to 30 years
Russia	Exploration Based	1 to 2	10 years
United States	Development Based	6 to 7†	10 years

* The number of wells shown is estimated based on 1 to 2 wells needed to establish an exploration discovery.

† The number of wells shown includes exploration and appraisal wells. Based on practices used in the Lower 48, securing a lease extension beyond the primary term requires a firm commitment to develop requiring multiple appraisal wells, engineering studies, and funding. One appraisal well per 200 million barrels of recoverable volume, and a field size of 1 billion recoverable barrels was assumed.

Table 4-1. *Lease/License Comparison by Country* serial E&A campaign relies on access to new acreage; understanding of the geology of a basin matures over time as new wells are drilled and new acreage accessed and the evolution of that knowledge brings into play new approaches as more wells are drilled in the basin. The effective application of this influx of new data is dependent on new acreage opportunities made available in more frequent and regularly spaced intervals. Staggering the lease expiration dates through new lease sales promotes continual activity within the basin. More frequent lease sales are also warranted given current OCS rules that require release to the public of specific well data 26 months following the completion of a well. Operators should be able to act to acquire acreage opportunities based on their proprietary findings and further explore and appraise their leases before the data is public.

Similarly, conducting an E&A campaign also relies on certainty that leased acreage will continue to be available over time. The DOI has the option to limit a sale to only certain areas. OCSLA regulations provide a collaborative process of identifying these areas to be leased. There is an initial request for industry to identify blocks within an OCS planning area in which they have interest, referred to as a "call for information." The public is also invited to comment on areas that should or should not be considered for leasing. The Bureau of Ocean Energy Management (BOEM) then analyzes the information received in addition to environmental and community objectives in the area, and then defines the proposed sale area, called "area identification," and issues a final notice of sale.

For the Chukchi Sea, BOEM has recently announced that certain environmentally sensitive areas will not be available for leasing. In applying this approach, care must be taken that lease and access rights already conveyed in the Chukchi are not compromised. In the longer term, if certainty of areas available for exploration over the life of the basin is increased with this targeted area approach, there are clear investment benefits; however, if over time more acreage is removed from exploration this can constrain the predictability and certainty that helps companies make the long-term decisions required for offshore development, particularly at the magnitude required for frontier areas like the Arctic. In addition, in determining the lease area, DOI initial requests to industry to identify areas of interest must take care to not require that potential lease bidders identify the specific or narrow block areas they consider most prospective as this can compromise proprietary company information. Operators typically need to develop a regional view of the basin as they explore rather than an OCS block or prospect view. This is especially true in frontier areas about which existing information can be limited. Clear and certain access to opportunities promotes the efficient development of the resource while changing and uncertain requirements prevent the most effective planning and mitigation activities. A more certain program also encourages robust participation in lease sales, which improves revenue from lease bids to the federal government. Uncertainty can also lead to increased surface disturbance and more activity as operators try to address difficult access requirements. DOI planning rules and the multitude of environmental statutes that govern exploration and development can, and do, ensure protection of sensitive areas.

In conclusion, in addition to the benefits previously described for longer lease terms, more frequent lease sales also promote energy security and economic growth as they can increase government revenue by encouraging more activity in a basin. Revenues from OCS leases consist of bonuses, royalties, and rentals and are collected by the Office of Natural Resource Revenue. These revenues are shared with coastal states in the Gulf of Mexico, as discussed in Chapter 3. The remaining funds are deposited in the U.S. Treasury. OCS revenues provide annual deposits of nearly $900 million to the Land and Water Conservation Fund and $150 million to the Historical Preservation Fund.[19] The last Chukchi Sea lease sale set a bonus bid record at $2.6 billion.

Work Plans

OCSLA regulations also require an operator who has ceased operating on a lease to resume operations within 180 days of lease expiry if they want to retain the lease.[20] This would be impossible in the Arctic due to the short exploration drilling season. The same section of OCSLA allows an operator to ask the regional supervisor to allow more than 180 days to resume operations on a lease beyond its primary term when operating conditions warrant. The request must be in writing and explain the operating conditions that warrant a longer period. In allowing additional time, the regional supervisor must determine that the longer period is in the national interest, and it conserves resources, prevents waste, or protects correlative rights.[21] A multi-year work plan concept, modified for the Alaska OCS, could satisfy these conditions and provide the predictability and certainty that is critical in a frontier area such as the U.S. Arctic.

Recommendations

To address insufficient lease duration, infrequent lease sales, and the difficulty in holding a lease unless drilling continues within 180 days of the initial lease term expiry, the following could be considered:

Lease Length

- The Department of Energy, working in collaboration with the Department of the Interior and with input from other stakeholders, should conduct an assessment of the timelines required to progress an offshore exploration prospect from lease through a decision to proceed to development. This assessment should be completed before the next lease sale.
  - These timelines should include the time to plan, permit, and safely execute seismic surveys, exploration drilling, and any necessary appraisal wells, as well as conduct and interpret results from these activities. The time required to complete engineering studies, including an economic feasibility assessment to enable a development decision, should also be included.
  - The assessment should consider the season length limitations imposed by the Arctic operating environment and ecological/subsistence considerations, as well as approaches used by other Arctic nations with similar geological and operating environments.
  - If warranted, based on this assessment, congressional action to amend the OCSLA to reflect the lease term for Arctic operations could be pursued. For existing leases, DOI could clarify suspension authority via a Notice to Lessees.

Lease Sales

- More frequent and predictable lease sales that maintain protections for lease rights should be considered.
  - Prior to lease sales, DOI could hold detailed consultations with operators and other stakeholders to examine critical issues specific to lease areas, and identify fit for purpose lease stipulations to be applied for the life of the lease. Any significant subsequent alterations to lease sale terms should continue to be justified by science and meet a cost-benefit test.

180-Day Term

- A work plan approach to meet the 180-day due diligence terms of the OCSLA should be pursued.
  - This could require submittal of a schedule of activity showing due diligence in E&A to the point where commercial viability can be determined, taking into account the short season length, scarcity of drilling assets, and logistical challenges. An approval process for multi-year work plans would be most suitable coupled with a directed suspension for times when operations cannot occur. BSEE should approve these work plans early enough in a lease term to minimize planning and investment uncertainty. BSEE could use the Notice To Lessees process to put this into effect.

Focused Conservation Measures Are Likely to Be More Effective Than Overly Broad Critical Habitat Designations

When appropriately identified and delineated, critical habitats are one of many important conservation tools, protecting the ability of plants and animals to thrive and be protected from direct harm. Through focused conservation measures, human activity may be restricted or prohibited in specific areas, which can contribute to sound environmental stewardship and environmental sustainability. Overly broad critical habitat designations, by contrast, have the potential to result in restrictions or uncertainty over very large areas with limited benefits. This approach could create a hindrance to economic growth and energy security, and even to human health and safety if operations cannot be conducted in optimal ways. If, on the other hand, overly broad designations result in few or no restrictions, then it is not clear that they provide any meaningful benefit to environmental stewardship or environmental sustainability. Alaska Native communities rely on marine mammals and other species for cultural, nutritional, and spiritual purposes, but their interests are not served either by ineffective conservation measures.

Critical habitat designations are required under the Endangered Species Act (ESA). Critical habitats can include areas of dense aggregations of a species, breeding areas, feeding areas, and other places that are necessary for essential behaviors and life history stages. Absolute prohibitions of activities are relatively rare under critical habitat designations and are most often limited to highly restrictive areas of habitat for critically endangered species (e.g., specific hot springs where desert pup fish occur or known nest locations for certain bird species). In most cases, existence of designated critical habitat within a project area requires an additional consultation among federal permitting agencies including consideration of mitigation measures that will protect the species, species habitat, and accommodate project activities.

Although the ESA calls for determination of critical habitat for listed species within 1 year of a listing determination, designations currently exist for fewer than half (661 of 1,499, as of March 1, 2013, according to the Fish and Wildlife Service) of species listed as threatened or endangered. Increasingly, however, species listing decisions, critical habitat designation, and recovery plans are being driven by litigation and settlement that impels the trustee agencies to make decisions on a timeline that is not supported by the available information or the funding for additional research needed to make high-quality decisions.[22] In the absence of sufficient information to focus critical habitat designation specifically upon areas that "contain the physical or biological features that are essential to the conservation of threatened species and that may need special management or protection," [23] critical habitats may be designated broadly to make sure they encompass the areas that meet the stricter criteria intended by the ESA. When critical habitats are defined too broadly, however, they may contribute little to conservation while raising obstacles to prudent development and significantly increasing the liability of proposed activities to litigation. This has been recognized by the courts, for example, in finding that polar bear critical habitat was too extensive and inadequately justified.[24]

A key difficulty with overly broad critical habitat designations is the considerable ambiguity that currently exists regarding what these designations mean and when during the life of a project critical habitat might be designated, thus changing the requirements for operations. To take one example, Arctic marine mammals either require or prefer sea ice habitats for much of the year.[25] If all sea ice throughout the year is designated as a critical habitat for one or more marine mammals listed under the ESA, any human activity in or around sea ice will be subject to the close scrutiny of an official consultative process that is itself subject to legal challenge, and may be affected by subsequent regulations concerning sea ice habitat. This includes icebreaking, ice management, and other activities that, for much of the year, are essential to safe offshore oil and gas operations in Arctic conditions and have few if any conservation impacts when conducted in accordance with existing practices for marine mammal protection (see below). The habitat limitations for ice-dependent marine mammals at present are the distribution of sea ice in relation to bottom depth, which affects walrus distribution and behavior, and the overall extent of sea ice in the Arctic Basin, which may affect polar bears. Neither of these parameters is affected to any measurable degree by icebreaking or ice management.

If a broad range of industrial activities is limited by critical habitat designations, then the ability to explore and develop Arctic oil and gas reserves may be similarly limited. The uncertainty associated with the regulatory effects of overly broad critical habitat designations makes planning difficult or impossible, adding a large uncertainty to industrial operations. It is important to note that the ESA is specific that potential economic impacts should be evaluated in relation to critical habitat designation and areas should be excluded from restrictions if the economic benefits outweigh conservation benefits, excepting where exclusion would result in extinction of the species, which is not a current concern for any Arctic marine mammal species.

A look at other countries suggests that the degree of uncertainty associated with overly broad critical habitat designations in the United States is unusual. Norway also designates "valuable and vulnerable areas" as part of its marine spatial planning approach. These areas can be extensive, but the rules in such areas tend to be clearly laid out, reducing ambiguity.[26] Canada, similarly, designates Ecologically and Biologically Significant Areas (EBSAs) and also critical habitats and other provisions under the Species at Risk Act. EBSAs cover half of Canadian Arctic waters, but the regulatory provisions and expectations for operators in those areas are usually clear.

In terms of achieving conservation goals in U.S. Arctic waters, targeted conservation measures already exist. For example, the Marine Mammal Protection Act governs any interaction between marine mammals and humans, including subsistence harvests by Alaska Natives as well as "incidental take" by industry and others. The permitting process for incidental take is well established and provides a clear benchmark for industry performance. During any offshore activity, and at all coastal industrial sites, marine mammal monitoring is conducted at all times, to identify potential interactions and take appropriate action in a proactive fashion. All such interactions are reported to the appropriate federal agency, in accordance with the permits that are issued to allow any incidental "take" (defined as harassing, harming, killing a marine mammal; few "takes" involve physical harm to an animal, and very few, if any, involve the death of a marine mammal).

Broad general areas of critical habitat designation are not uncommon under the ESA in cases where precise mapping is impractical or unwieldy.[27] In such cases, the designation proposal frequently narrowly defines those specific habitat characteristics and timing that can be differentiated from the total area of a species' range. Such specificity should ideally be incorporated in designation documents to provide guidance to consulting personnel with the appropriate federal agency. In this way, critical habitat designation can be used appropriately as one among many conservation tools in the pursuit of prudent development.

Recommendations

- The available tools for and knowledge of species and ecosystem conservation should be evaluated to determine how best to achieve desired environmental benefits while avoiding unnecessary restrictions on, or uncertainty in planning of, oil and gas operations.
  - The U.S. Fish and Wildlife Service and/or the National Oceanic and Atmospheric Administration (the agencies with responsibility for marine mammals and seabirds in Arctic Alaska) should evaluate existing conservation measures, weighing their conservation efficacy against the degree to which human activity is restricted (i.e., through the lens of prudent development). This should be done with the involvement of industry, Alaska Native organizations, and the conservation community. Doing so should help in the design of an efficient, effective conservation strategy for species and habitats in Arctic Alaska.
  - The same agencies should develop a plan for and take the lead in carrying out ecological research and analyses to distinguish critical habitat areas within the overall range of a given species, again in cooperation with the same stakeholders. Improved understanding will allow more targeted and focused habitat conservation efforts in areas that are indeed crucial to a species, while avoiding unnecessary restrictions on human activity elsewhere, fostering economic growth and energy security and potentially improving human health and safety. Combined with other conservation measures, such an approach is fully consistent with the environmental stewardship and environmental sustainability requirements of prudent development.
  - Appropriation of sufficient funds to support the research to develop accurate and targeted critical habitat designations is essential to accomplishment of conservation mandates and economic imperatives.

Efficient and Cost-Effective Development Can Be Facilitated with Appropriate Policy and Regulations

Several policy and regulatory items have been identified that, while not directly tied to research needs, have the potential to significantly facilitate efficient and cost-effective prudent development of U.S. Arctic resources. As such, the DOE could play a role to encourage efforts for change in these areas. Optionality for hydrocarbon export, pipeline corridor right of ways, a suitable and efficient statewide wetlands compensation mitigation plan, and access to limited gravel deposits are all critical for development. Additionally, access to suitable Arctic-capable and cost-effective marine vessels is key to providing the best possible chance for environmentally sustainable, safe, cost-effective, and economically viable development of U.S. Arctic oil and gas resources.

A variety of hydrocarbon transportation methods including pipeline, railway, and tankers may be required to efficiently and effectively develop a hydrocarbon discovery. This openness to consider all viable alternatives enabled the developers of Prudhoe Bay to identify the Trans-Alaska Pipeline System (TAPS) as the preferred transportation method to balance reliability, energy security, and environmental stewardship with economic growth. The key to establishing the economic viability of the pipeline option was the sheer size of the resource, and, at almost 20 billion barrels ultimate recovery, the $8 billion TAPS pipeline was economic. However, a smaller field probably would not have justified such investment at that time.

Since TAPS was placed into service, oil production has declined on the North Slope, with TAPS throughput dropping from a peak of more than 2 million barrels a day to a 2013 average of approximately half a million barrels per day.[28] With further reduction in throughput, TAPS could cease flow as discussed in Chapter 2. If this occurred, as well as stranding significant oil and gas resources, Alaska's oil and gas based economy would be jeopardized.

While future developments could extend the life of TAPS, consider both that the initial resource size needed to justify TAPS and that the prospective hydrocarbon areas of the U.S Chukchi OCS are 400 miles from TAPS. As such, it follows that selecting the right hydrocarbon transport option and ensuring access to onshore lands required for development is critical to facilitate the most economical and prudent development concept to be progressed.

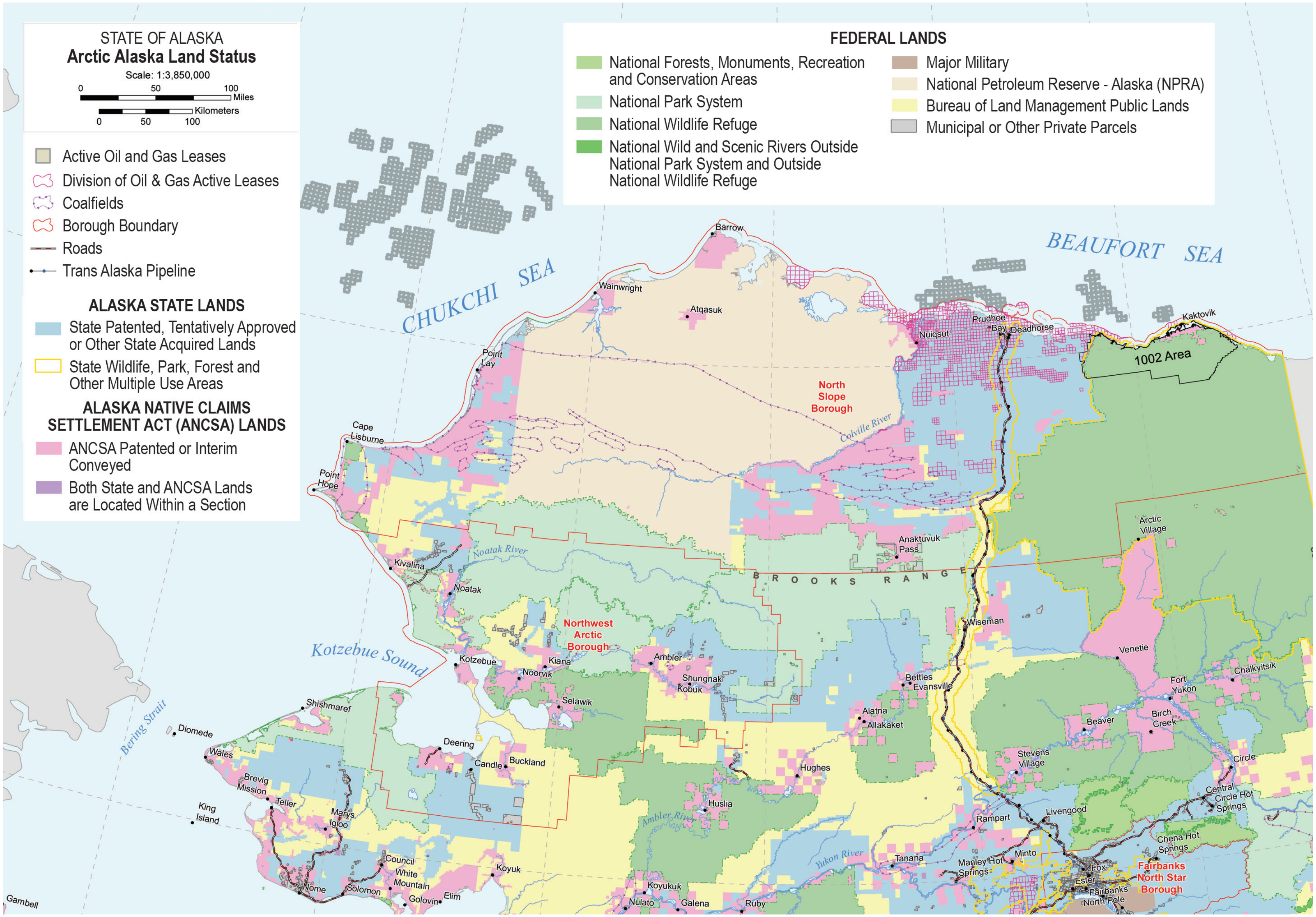
Access to lands, including subsurface gravel deposits and wetlands, are critical to the prudent development of both the onshore and offshore hydrocarbon resources. The U.S. federal government is the largest landowner in the state of Alaska, with ownership of 60% of Alaska's 365 million onshore acres,[29] as shown in Figure 4-3. In addition, Alaska's coastline accounts for more than half the miles of coastline of the entire United States,[30] and all waters outside of Alaska's 3-mile territorial limit are under federal control. To ensure that offshore discoveries can be efficiently and prudently developed and to facilitate the sustainability of TAPS, companies require reasonable and cost-effective access to these areas in a way that connects the discovery with existing infrastructure.

However, current access rules and management regimes for the NPR-A and the Arctic National Wildlife Refuge (ANWR) could likely restrict or prohibit efficient development in and around these areas, thereby jeopardizing the resource needed in the short and medium term to sustain TAPS. National Wildlife Refuge System managers deny access for oil and gas transportation and production related utility and other rights-of-way corridors by finding these activities "incompatible" with the refuge's purpose and need. In contrast, the Alaska National Lands Interest Conservation Act was written with the intent that state and other landowners would have access across conservation lands for such necessary corridors, however, this intent has been gradually eroded by subsequent regulations and management plans. As a result, access corridors and areas needed for any discoveries made offshore near ANWR would be very difficult to obtain and could result in alternative corridors being proposed that are less environmentally sustainable and more costly, and may ultimately result in a discovery not being economically viable to develop.

Furthermore, in the NPR-A, the Bureau of Land Management's 2013 Record of Decision on the Final Integrated Activity Plan/Environmental Impact Statement (IAP/EIS) restricts multiple land use of specially designated areas. This could potentially prevent construction and operation of a pipeline across NPR-A from the Chukchi to TAPS. Furthermore, a stipulation in Lease Sale 193 (Chukchi)[31] uses language that, while not categorically excluding the use of tankers as a transport option, also does not make specific reference to their acceptability. This apparent contradiction that, on one hand advocates the use of pipeline export, while on the other hand restricts the use of the NPR-A for pipeline rights of way, creates significant uncertainty when planning for development and could limit the use of either export option as a potentially suitable concept.

The NPR-A Final IAP/EIS also discusses sand and gravel resources.[32] The IAP/EIS points out that the state of Alaska issued a directive calling for the reuse/recycling of gravels on North Slope state lands due to the "general scarcity of suitable material and an attempt to limit additional mining activities in river systems." While the disposal of sand and gravel in the NPR-A is specifically authorized to be used in energy production and development, the IAP/EIS also describes the areas north and west of the Colville River area as being characterized by an "apparent scarcity of suitable construction materials."

The state's Division of Geological and Geophysical Surveys (DGGS) prepared a discussion paper



Source: Alaska Department of Natural Resources, Support Services Division, Information Resource Management.

Figure 4-3. *Land Ownership, Political Subdivision, and Leased Tracts Map for Areas North of the 65 Degree Latitude Line* about the availability of construction materials between the Colville River and the Chukchi Sea for this study.[33] DGGS identifies the lack of information about the availability of sand and gravel in the Chukchi Sea-Colville River corridor, and describes sand and gravel resources as "not obviously abundant," which presents challenges for development of production from the NPR-A as well as for pipeline construction and the associated infrastructure that would bring Chukchi Sea production to the Dalton Highway to tie-in to the TAPS. More complete information about the materials available across the northern sections of the NPR-A will be essential to successful development of further production within the reserve and of infrastructure associated with Chukchi Sea development.

In addition to the need for access to surface lands and subsurface gravel deposits, an appropriate model for wetlands compensatory mitigation that reflects Alaska's unique wetlands characteristics and facilitates prudent and cost-effective development is critical. Alaska's wetlands cover approximately 174 million acres, or about 43% of Alaska's surface area,[34] and as a result, most development projects where onshore support for offshore development is likely to occur, will require the Clean Water Act's Section 404 permitting and some form of wetlands compensatory mitigation. However, the current system to determine such compensation has several drawbacks:

- The U.S. Army Corps of Engineers (USACE) is responsible for administering Section 404[f] of the Clean Water Act and has recently rescinded its guidance (RGL 09-01) on the preparation of wetland functional analyses. Instead the USACE has requested that all applicants prepare an aquatic site assessment (ASA) but has provided little guidance on ASAs. The ASA is used to determine the appropriate category of wetland impacts for purposes of assigning a mitigation ratio that can be translated into an in-lieu mitigation fee. This change and lack of regulatory guidance introduces uncertainty for companies seeking to develop hydrocarbon resources in wetland areas.
- When the current federal no net loss policy for wetlands and aquatic resources was being developed, federal regulators recognized that Alaska's wetlands were ubiquitous and were not rapidly declining as was the case with wetlands in the Lower 48 states. To recognize this, the "Alaska Initiative" was proposed in 1994 and ultimately concluded that a flexible regulatory framework was necessary to reflect circumstances in Alaska.[35] Despite this, the Alaska Initiative is not currently in effect.
- The Conservation Fund is currently the sole provider of a federally approved in-lieu fee compensatory mitigation program for projects on the Arctic Slope of Alaska. The Conservation Fund recently published a new in-lieu fee program instrument where the cost per acre for any gravel fill depending on wetland type and function could be as high as $44,000 per acre. [36] This cost per acre has significantly increased over time and poses a real threat of making potentially viable resource development projects for economic growth no longer feasible.

While access to onshore lands is required to support and tie back offshore developments, the development of offshore resources can also not occur if appropriate Arctic-capable marine vessels cannot be acquired. For oil and gas activities, ice-strengthened and winter-hardened drilling ships, emergency and oil spill response vessels, icebreaking vessels, tankers, tugboats and pipe-lay, trenching and supply vessels are all required. However, the global market has both a limited supply of these that are capable of operating in the polar regions and a limited number of ship yards capable of building such vessels. Furthermore, the Merchant Marine Act of 1920, commonly referred to as the Jones Act, places additional restrictions on vessel use between United States ports as it requires U.S. flagged, owned (75%), and crewed vessels to be used.

As an example of the need to access ice-hardened tankers, in the recent (October 2014) BOEM issued Draft Second Supplemental Environmental Impact Statement for the Chukchi Sea, the statement is made that tanker offloading is not a viable strategy. One of the supporting arguments noted, is that "to be compliant with the Jones Act, the tankers would have to be constructed in the U.S. The timing and logistics of constructing the ice-hardened tankers would be difficult given that none have ever been built in the U.S. and that the U.S. shipbuilding industry has little experience with icebreakers in general."[37] This

f Section 404 of the Clean Water Act establishes a program to regulate the discharge of dredged and fill material into waters of the United States. The phrase "waters of the United States" defines the extent of geographic jurisdiction of the Section 404 program. The term includes such waters as rivers, lakes, streams, and most wetlands. Regulated activities include fills for development, water resource projects, infrastructure development and conversion of wetlands to uplands for farming and forestry.

example highlights the difficulty of accessing the required vessels, limits the use of potentially viable hydrocarbon export development options and therefore poses a threat to cost-effective and efficient access to the ice class vessels required for many U.S. Arctic exploration and development activities.

Furthermore, the limited availability of oil and gas Arctic specialty vessels, the remoteness of the U.S. Arctic, the number of vessels required for oil and gas exploration and development, and the lack of critical infrastructure present major logistical challenges for prudent exploration and development. A typical non-self-propelled drilling unit may require up to three or more ocean going tugs to tow to location. Once on location, two to three anchor handling vessels may be needed to deploy anchors to keep the drilling rig in position. Furthermore, the drill rigs have around 120 to 150 personnel on board and require resupply of drilling materials and perishable provisions while on location. With the nearest deepwater port more than 1,000 nautical miles away, multiple offshore supply vessels (and possibly a floating supply base) would be required to provide this service. Moreover, several vessels would be required for fuel resupply and to transport waste from site for suitable disposal, and a dedicated vessel is required as part of the National Pollutant Discharge Elimination System permit specifically to complete the environmental monitoring program as described in Chapter 9. Additionally, oil spill, and emergency response vessels would be on continuous standby in the region. In total, approximately 25 vessels and barge/tug combinations would be required to support a two-rig open water exploratory drilling program.

Once development starts, vessel requirements will only be greater. Specialized vessels such as pipe-lay, dredging and trenching vessels, and well maintenance vessels will also be required to support facility installation and year-round operations and, in the case of oil export by tanker, several oil tankers, associated support craft, and potentially additional escort icebreakers will be required to transport the produced hydrocarbons.

When comparing U.S. practices with other countries, Canada's Coasting Trade Act provides practical solutions. The Coasting Trade Act generally requires a Canadian flagged vessel to be used if it exists and is available; however, exemptions can be, and many have been, granted for up to 12 months if there are no suitable Canadian vessels available to perform the service or activity.[38]

In summary, flexible and consistent terms of access across federal lands and ensuring that reasonable options for wetlands compensatory mitigation are utilized can facilitate efficient development and, in the case of pipeline routing, may allow for more optimum and cost-effective placement that limits surface impact. Additionally, promoting consistency in regulatory decisions and providing optionality for hydrocarbon export options reduces uncertainty, increases the likelihood of development, and provides a positive impact on Alaska's oil and gas dominated regional economies. Furthermore, and specifically for offshore developments, timely and cost-effective access to the Arctic-capable vessels will facilitate safe, environmentally sustainable and economic development.

Recommendations

The Administration should champion policies that enable effective and efficient logistics and infrastructure. Examples of current regulatory requirements that constrain Arctic development include:

- Limited access to federal lands for oil and gas transportation systems where no practical alternative exists.
  - Allow reasonable access, for example through a transparent Alaska National Lands Interest Conservation Act Title XI process, across ANWR and other conservation unit lands for transportation and utility (oil and gas transportation) systems where no practicable alternative exists.
  - Revise the NPR-A IAP Record of Decision to impose Alternative D to remove many barriers and limitations on access to effective and efficient rights of way corridors.
- Presupposing oil transport solution for potential new discoveries.
  - Allow adaptive management and phased decision-making processes to facilitate decisions that are based upon the actual resource discovered in a particular location.
  - Provide optionality within permit and lease conditions for consideration of all viable hydrocarbon transport methods and ensure consistent guidance among agencies.

- The Jones Act rules on tankers and support vessels mandate largely unavailable and uncompetitively priced ships, unduly increasing the cost of operations in the U.S. Arctic.
  - Consider providing exemptions to the Jones Act for the non-U.S.-flagged, ice class vessels used in U.S. Arctic exploration and appraisal operations. This will ensure that ice class vessels are available at competitive rates given the long lead times required for Arctic offshore operations.
- Wetlands mitigation requirements that are inconsistent with the ecological landscape of Alaska and impractical to execute.
  - Support additional wetlands hydrological and ecological function research to develop a statewide mitigation plan (research typically conducted by the USACE or other regulatory agencies).
  - Implement a more flexible and effective regulatory approach that considers all mechanisms of wetlands mitigation including mitigation banking, in-lieu fee mitigation, and permittee-responsible mitigation.
  - The USACE could evaluate the "Alaska Wetlands Initiative" for appropriateness and suitability and consider re-implementing it. The USACE could also standardize and make available its regulatory guidance on the preparation of wetland functional analyses (aquatic site assessments).

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Part One

Additional References

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