

2017 Assessment of Undiscovered Oil and Gas Resources in the Western Beaufort Sea OCS Planning Area

Using a play-based assessment methodology, the Bureau of Ocean Energy Management estimates a mean of 1,229 million barrels of undiscovered technically recoverable oil and 0.892 trillion cubic feet of undiscovered technically recoverable natural gas in two plays in the Cretaceous Brookian sequence in the western Beaufort Sea OCS.

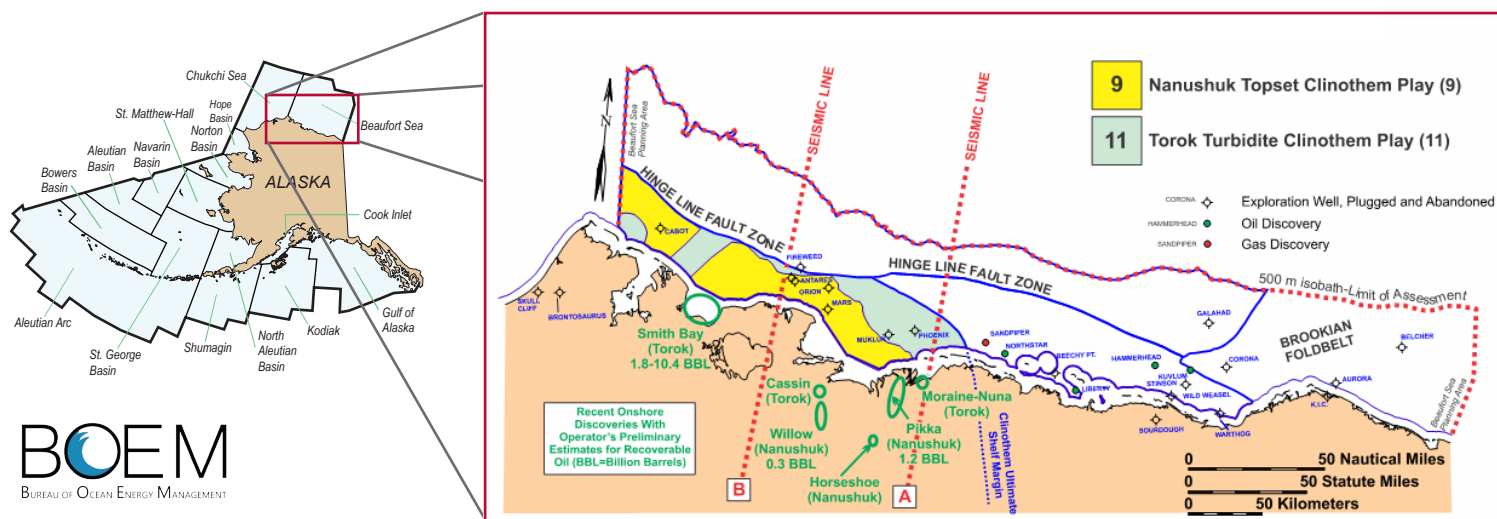


Figure 1. Map showing extents of the Nanushuk Topset Clinothem (yellow) and Torok Turbidite Clinothem (green) plays.

Introduction

This fact sheet summarizes a Bureau of Ocean Energy Management (BOEM) update to the existing 2016 assessment of two oil and gas plays in the Beaufort Sea Planning Area (Figure 1). This undiscovered technically recoverable resource assessment update was prepared through a collaborative effort between BOEM and the USGS in response to the May 31, 2017 Secretarial Order 3352. This Secretarial Order directed the Assistant Secretary – Land and Minerals Management and the Assistant Secretary – Water and Science to update current assessments of undiscovered technically recoverable oil and natural gas resources of Alaska’s North Slope, focusing on Federal lands including the NPR-A and the Section 1002 Area of the Arctic National Wildlife Refuge (ANWR). This fact sheet presents only those results specific to the Beaufort Sea Planning Area on the Outer Continental Shelf (OCS) that were updated in response to Secretarial Order 3352.

The OCS comprises the portion of the submerged seabed whose mineral estate is subject to Federal jurisdiction. This 2017 assessment represents a comprehensive update appraisal that considers data and information relevant to the Nanushuk and Torok Formations that were available as of May 31, 2017 and builds upon previous assessments of the Beaufort Sea OCS planning area. These plays extend from the three nautical mile State-Federal OCS boundary north to either the Nanushuk-Torok terminal paleo-shelf margin (Figures 1 and 2) or the Hinge Line fault system (Figures 1 and 2).

This assessment provides estimates of undiscovered technically recoverable resources (UTRR) located outside of known oil and gas fields on the OCS. It considers recent geophysical, geological, and technological information and utilizes a probabilistic play-based approach to estimate the UTRR for individual geologic plays. This methodology is suitable for both conceptual plays where there is little specific information available and for developed plays where

considerable information from discovered oil and gas fields is available. Individual geologic play results are aggregated to larger areas including planning areas and entire regions.

Commodities Assessed

Commodities assessed include crude oil, natural gas liquids (condensate), gas dissolved in hydrocarbon liquids (solution gas), and “free” natural gas that occurs in gas-only pools and in separate pools capping oil pools. These resources exist in conventional reservoirs and are producible with conventional recovery techniques. Crude oil and condensate are reported jointly as oil; associated (here, solution gas) and non-associated (here “free”) gas are aggregated as gas. Oil volumes are reported as millions of stock tank barrels (MMSTB) and gas as billions of standard cubic feet (BSCF) or trillions of standard cubic feet (TSCF). Oil-equivalent gas is a volume of gas (solution and/or non-associated) expressed in terms of its energy equivalence to oil (i.e., by BOEM convention calculated as 5,620 cubic feet of gas per barrel of oil). The combined volume of oil and oil-equivalent gas resources is reported in barrels of oil-equivalent (BOE) and is reported in Table 2 as millions of barrels-equivalent (MMSTB-e).

This assessment does not include potentially large quantities of hydrocarbon resources that could be recovered from known and future fields by enhanced recovery techniques. It also does not consider methane hydrates, gas in geo-pressured brines, or oil and natural gas that may be present in insufficient quantities or in reservoirs of such poor quality (low permeability or “tight”) that extraction by conventional recovery techniques is precluded.

Estimates of UTRR are generated stochastically and are reported at the mean value and at the 95th and 5th percentile values. This range of estimates corresponds to a 95 percent probability (a 19 in 20 chance)

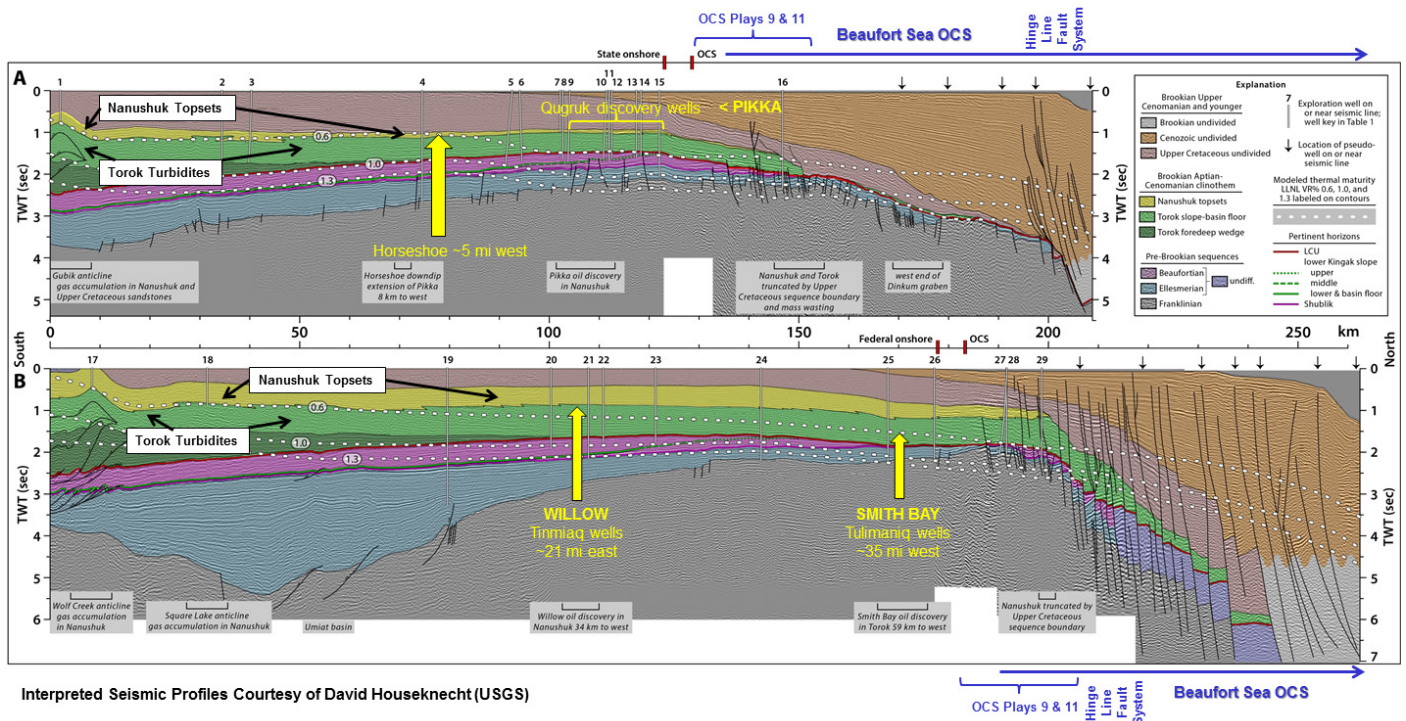


Figure 2. Seismic lines illustrate the continuity of the Nanushuk (highlighted in yellow) and Torok (green) Formations from the onshore area of recent oil discoveries north into Federal waters of the Beaufort Sea OCS. In the Beaufort Sea OCS, the Nanushuk Topset Cliniothem and Torok Turbidite Cliniothem plays extend north to either a stratigraphic termination at the maximum progradation of the Nanushuk-Torok cliniothem (seismic line A) or to the Hinge Line fault system, where the two formations are dissected by closely-spaced faults and abruptly descend to great depths (seismic line B). In the unfaulted areas of the two plays, the prospects are stratigraphic in nature and require three-dimensional (3D) seismic data for identification. No 3D seismic data are available for these two OCS plays. The locations of seismic lines A and B are shown in Figure 1.

and a 5 percent probability (a 1 in 20 chance) of there being more than the corresponding amounts present, respectively. The 95 and 5 percent probabilities are considered reasonable minimum and maximum values, and the mean is the average or expected value.

Methodology

The 2017 assessment update incorporates a play-based approach that provides a strong relationship between information derived from oil and gas exploration activities and the geologic model developed by the assessment team. The geographic limits of each of the two updated plays were refined and data on geologic and reservoir engineering parameters were updated. The BOEM assessment model utilizes a probabilistic approach to account for the inherent uncertainties associated with an assessment of undiscovered resources. Results are reported as a range of values corresponding to different probabilities of occurrence, as noted above.

Due to the sparse data that characterize many of the geologic plays in the Alaska OCS Region, analog plays are developed with a subjective approach to cover the range of uncertainties associated with these plays. Assessments of some Alaska plays are informed by commercial developments of analogous fields onshore where performance histories reveal information about the reservoir quality and lateral connectivity that control recovery efficiencies (recovered fraction of in-place hydrocarbon volumes).

Three-dimensional (3D) seismic data in five surveys in NPR-A were analyzed to quantify the numbers and sizes of far-trace¹ reflection-amplitude anomalies or “geobodies” that form proxies for prospects in the rock formations that host recent discoveries in the onshore North Slope (Figure 1) and that extend directly offshore into the Federal OCS

(Figure 2). The new discoveries are stratigraphic traps that are difficult to image using only two-dimensional (2D) seismic data. Although no 3D seismic data have been acquired on the Beaufort Sea OCS for the plays targeted by this update assessment, BOEM does have access to the 3D seismic data in NPR-A to conduct fair-market valuations of bids received on tracts offered in NPR-A lease sales.

The Nanushuk “Topset” and Torok “Turbidite” Formations and their continuity into the Beaufort Sea OCS are illustrated by the two seismic lines presented in Figure 2. The 3D seismic mapping in the correlative formations onshore supports the updated forecasts of numbers and sizes of prospects in the Nanushuk Topset Cliniothem and Torok Turbidite Cliniothem plays in the Beaufort Sea OCS. The extrapolation of 3D seismic mapping onshore to these offshore plays is key to this assessment update. Table 2 provides geologic input data and internal calculations (prospect numbers and areas, pool numbers and areas, pay thickness, and oil and gas recovery factors). Based upon the extrapolation of geobody densities derived from 3D seismic surveys, the maximum number of prospects forecast for the Nanushuk Topset Cliniothem play offshore was increased from 15 (2016) to 311 (2017). Similarly, the maximum number of prospects for the Torok Turbidite Cliniothem play offshore was increased from 12 (2016) to 795 (2017). These increases in prospect numbers formed powerful drivers for the increased resources forecast by the update for the Nanushuk Topset Cliniothem play and countered a decrease in resources for the Torok Turbidite Cliniothem play driven by reservoir performance considerations.

Note that the probability distributions for prospect areas in Table 2 are highly skewed, ranging from an adopted minimum cutoff of 100 acres to 75,000 acres. Many geobodies in the range from 10 acres to 100 acres (52% of the entire population of 715) observed in the Nanushuk topset

¹Far-Trace: the amplitudes of reflections as measured at the far ends of seismic gathers where the angle of departure from vertical (zero trace) is maximized and where sensitivity of the seismic response to porosity and hydrocarbons is greatest.

Planning Area Geologic Play	Risky Undiscovered Technically Recoverable Oil and Gas Resources (UTRR)								
	Oil (MMSTB)			Gas (TSCF)			BOE (MMSTB-e)		
	95%	Mean	5%	95%	Mean	5%	95%	Mean	5%
Beaufort Sea	4,402	8,902	15,441	14.390	27.740	42.202	6,962	13,838	22,950
Undeformed Pre-Miss. Basement	0	16	60	0.000	0.083	0.320	0	31	117
Endicott Play	33	261	796	0.070	0.524	1.572	46	354	1,076
Lisburne Play	0	139	689	0.000	0.224	0.983	0	179	864
Upper Ellesmerian Play	275	1,254	2,930	0.514	2.282	5.395	366	1,660	3,891
Rift Play	0	801	2,441	0.000	2.002	4.804	0	1,157	3,296
Brookian Faulted Western Topset	0	242	983	0.000	2.090	7.027	0	614	2,234
Nanushuk Topset Clinotherm	12	1,083	4,330	0.181	0.683	1.893	44	1,205	4,666
Brookian Faulted Western Turbidite	0	60	200	0.000	0.967	3.457	0	232	815
Torok Turbidite Clinotherm	0	146	515	0.000	0.209	0.628	0	184	627
Brookian Faulted Eastern Topset	0	1,053	3,046	0.000	9.991	22.860	0	2,831	7,114
Brookian Unstructured Eastern Topset	104	579	1,440	0.065	0.336	0.758	116	639	1,575
Brookian Faulted Eastern Turbidite	0	240	581	0.000	3.938	9.962	0	941	2,354
Brookian Unstructured Eastern Turbidite	0	123	393	0.000	0.250	0.787	0	168	533
Brookian Foldbelt	0	2,905	7,628	0.000	4.161	11.348	0	3,645	9,647

Table 1. Risked Undiscovered Technically Recoverable Resources of Beaufort Sea and included geologic plays. Resource values are in million barrels of oil (MMSTB) and trillion cubic of gas (TSCF). 95% indicates a 95 percent chance of at least the amount listed; 5% indicates a 5 percent chance of at least the amount listed. Only mean values are additive. Some total mean values may not equal the sum of the component values due to independent rounding. Values for UTRR results are for both leased and unleased lands of the Federal OCS.

sequence onshore were excluded from the prospect area probability distribution model to moderate the skew of the size distribution. Nonetheless, the probability distribution for the remaining geobodies remains highly skewed toward small features. Mean values of the prospect area distributions are low relative to the observed size spectrum (3,845 acres for the Nanushuk Topset Clinotherm play and 3,557 acres for the Torok Turbidite Clinotherm play).

The probability distributions for pool numbers (Table 2) are calculated by aggregating the probability distribution for prospect numbers with the exploration chance calculated from the play risk models (0.35 for the Nanushuk Topset play; 0.24 for the Torok Turbidite play).

Table 2 also provides some details about the ranges of conditional (not discounted by risk) sizes (oil and gas volumes) of the largest and smallest pools. Each pool is reported with a wide range of potential sizes and associated probabilities. In the case of the largest pool in the Nanushuk Topset Clinotherm play, the full range (F100 to F00, or 100% to 0% chance to exceed) in possible oil (+condensate) resources is from 0.06 to 16,345 million barrels, with a mean or expectation of 635 million barrels.

The BOEM resource assessment process included a review of all variables that support geologic play analysis; probability distributions for these variables were updated to reflect new data. One of the most

significant updates involved the downgrading of the oil recovery factor (recovery per unit rock volume) for the Torok Turbidite Clinotherm play. The results of oil development in the Torok Turbidite accumulation at the Nanuq pool in the (State of Alaska) Colville River unit onshore led to a significant decrease of the recovery efficiency (recovered fraction of original oil or gas in place) for the correlative Torok Turbidite Clinotherm play offshore. Pool statistics and a pool map published by the Alaska Oil and Gas Conservation Commission (AOGCC, 2011) indicate 187 MMSTB of original oil in place (BOEM estimate). The pool has been in production for 12 years, is in rapid decline, and seems unlikely to ultimately produce more than 5 MMSTB, or 2.7% of the original 187 MMSTB oil in place. An alternative but unlikely decline model forecasts 10 MMSTB in ultimate production or 5.3% recovery efficiency. The 2016 BOEM assessment for the Torok Turbidite Clinotherm play 11 assumed a median recovery efficiency of 25% (range, 11-55%) whereas the current assessment assumed a median recovery efficiency of 10% (range, 4-23%).

An upgrade of the oil recovery factor for the Nanushuk Topset Clinotherm play is based upon the discovery of the high-gravity (44° API) and (implied) low-viscosity oil (AKDNR, 2017) in the Willow sandstone (part of Nanushuk topset) that suggests high productivity when developed. The 2016 mean recovery factor of 216 STB/acre-ft (range 59-702 STB/acre-ft) assumed 25 °API oil; the 2017 mean recovery factor of 261 STB/acre-ft (range 63-655 STB/acre-ft) assumes

Assessment Input Data and Calculated Results	Nanushuk Topset Clinothem						Torok Turbidite Clinothem					
	100%	95%	50%	Mean	5%	0%	100%	95%	50%	Mean	5%	0%
Prospect Number	5	7	23	28	65	311	4	7	27	38	105	795
Pool Number (Calculated)	1	2	8	12	27	135	0	1	7	10	28	220
Prospect Area (Acres)	100	720	2,736	3,845	10,609	75,000	100	680	2,587	3,557	9,631	70,000
Pool Area (Acres, Calculated)	28	308	1,241	1,778	5,008	47,075	40	303	1,172	1,645	4,539	34,710
Pay Thickness (ft)	15	51	119	139	292	1,000	35	73	115	121	192	400
Oil Recovery Factor (STB/Acre-ft)	63	152	253	261	397	655	17	36	60	62	98	175
Gas Recovery Factor (MSCF/Acre-ft)	52	202	447	463	790	1,330	24	74	176	186	330	766
Largest Pool: (oil + condensate) (MMSTB)	0.06	35	218	635	2,989	16,345	0.04	6	29	77	335	1,749
Largest Pool: Gas (free + solution) (BSCF)	0.1	27.7	178.7	347.0	1,296.2	6,681.5	0.1	8.9	49.4	103.8	395.4	1,994.0
Smallest Pool: (oil + condensate) (MMSTB)	0.06	0.10	0.61	0.76	2	16,345	0.04	0.05	0.15	0.19	0.46	1,749
Smallest Pool: Gas (free + solution) (BSCF)	0.1	0.2	1.2	1.5	3.6	6,681.5	0.09	0.11	0.3	0.4	1.0	1,994.0
Pay Probability (Fraction)	1						1					
Exploration Chance (Fraction)	0.35						0.24					
Play Area (Acres)	1,192,232						1,933,605					
Play Area (Km ²)	4,825						7,825					

Table 2. Key assessment input data for two conventional plays of the Beaufort Sea OCS Planning Area with resource potential in the Nanushuk and Torok Formations. Percentages represent chance of at least that value being listed. For example, 95% indicates a 95 percent chance of at least the amount listed.

35 °API oil. An upgrade of the oil recovery factor is also supported by a flow test of a 2,000-ft lateral in the Nanushuk Formation at the Qugruk 301 well (Pikka unit) that yielded 30°API oil at tubing-constrained rates as high as 4,600 STB/day (PRNewswire, 2015; VanDenburg, 2017).

Assessment Results and Comparison to Past Assessments

The 2017 assessment update for the Nanushuk Topset Clinothem play (9) increases the mean risked energy composite (oil and gas in energy-equivalent barrels) from 475 MMSTB-e in 2016 to 1,205 million barrels in the new assessment (Table 1), an increase of 255% over the 2016 estimate. The increase was driven primarily by the forecast for larger numbers of prospects based on the geobody analysis in the onshore 3D seismic data.

The mean risked energy composite (oil and gas in energy-equivalent barrels) for the Torok Turbidite Clinothem play decreases from 218 MMSTB-e in 2016 to 184 MMSTB-e in the current 2017 assessment (Table 1), a decrease of 18%. The forecast for larger numbers of prospects based upon the interpreted geobody population was offset in part by the dominance of small features in the geobody population and in part by the downgraded estimates for oil and gas recoveries based on performance in the analog Nanuq field onshore.

When combined, the mean UTRR (risked energy composite) for the two Beaufort Sea plays in this assessment is 1,389 MMSTB-e, which represents a net increase of 696 MMSTB-e over the 2016 estimate of 693 MMSTB-e. The updates to these two plays increased the mean aggregated Beaufort Sea OCS planning area UTRR from 13,142 MMSTB-e in 2016 to 13,838 MMSTB-e in 2017 (Table 2). The Nanushuk Topset and Torok Turbidite Clinothem plays remain minor contributors (10% in aggregate) to the resource characterization of the entire Beaufort Sea OCS planning area. The Brookian Foldbelt play remains the dominant Beaufort Sea OCS play, with a mean UTRR of 3,645 MMSTB-e (26% of overall planning area UTRR).

List of Terms

Analogous Reservoirs: Reservoirs that have similar rock and fluid properties, reservoir conditions (depth, temperature and pressure), and drive mechanisms, but are typically at a more advanced stage of development than the reservoir of interest and thus may provide concepts to assist in the interpretation of more limited data and estimation of recovery.

Conventionally Recoverable: Producible by natural pressure, pumping, or secondary recovery methods, such as gas or water injection.

Field: Area consisting of a single reservoir or multiple reservoirs all grouped on, or related to, the same general geologic structural feature and/or stratigraphic trapping condition. There may be two or more reservoirs in a field that are separated vertically by impervious strata, laterally by local geologic barriers, or by both.

Pool: A discovered or undiscovered accumulation of hydrocarbons, typically within a single stratigraphic interval.

Play: A group of pools that share a common history of hydrocarbon generation, migration, reservoir development, and entrapment.

Probability: A means of expressing an outcome on a numerical scale that ranges from impossibility to absolute certainty; the chance that a specified event will occur.

Prospect: A geologic feature having the potential for trapping and accumulating hydrocarbons; a pool or potential field.

Resources: Concentrations in the earth's crust of naturally occurring liquid or gaseous hydrocarbons that can conceivably be discovered and recovered.

Undiscovered Resources: Resources postulated, on the basis of geologic knowledge and theory, to exist outside of known fields or accumulations. Included also are resources from undiscovered pools within known fields to the extent that they occur within separate plays.

Undiscovered Technically Recoverable Resources (UTRR): Oil and gas that may be produced as a consequence of natural pressure, artificial lift, pressure maintenance, or other secondary recovery methods, but without any consideration of economic viability. They are primarily located outside of known fields.

Selected References

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For Further Information

Supporting geological studies, previous assessment results, and methodologies used by BOEM for resource assessment can be found on BOEM's web site, www.boem.gov.

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