Chukchi Sea Play 17: Torok Turbidites (Lower Brookian)-Arctic Platform

Geological Assessment
GRASP UAI: AAAAA DAR
Play Area: 15,837 square miles
Play Water Depth Range: 150-170 feet
Play Depth Range: 4,500-10,000 feet
Play Exploration Chance: 0.03276

Play 17, Torok Turbidites (Lower Brookian)-Arctic Platform, Chukchi Sea OCS Planning Area, 2006 Assessment, Undiscovered Technically-Recoverable Oil & Gas		
Assessment Results as of November 2005		
Resource Commodity (Units)	Resources *		
	F95	Mean	F05
BOE (Mmboe)	0	139	338
Total Gas (Tcfg)	0.000	0.337	0.846
Total Liquids (Mmbo)	0	79	187
Free Gas** (Tcfg)	0.000	0.257	0.658
Solution Gas (Tcfg)	0.000	0.081	0.188
Oil (Mmbo)	0	65	150
Condensate (Mmbc)	0	14	38
* Risked, Technically-Recoverable		
** Free Gas Includes Gas Cap and Non-Associated Gas		
F95 = 95% chance that resources will equal or exceed the given quantity		
F05 = 5% chance that resources will equal or exceed the given quantity		
BOE = total hydrocarbon energy, expressed in barrels-of-oil-equivalent, where 1 barrel of oil = 5,620 cubic feet of natural gas		
Mmb = millions of barrels		
Tcf = trillions of cubic feet		

Table 1

Play 17, the "Torok Turbidites-Arctic Platform" play, is the 19th-ranking play (of 29 plays) in the Chukchi Sea OCS Planning Area, with 0.5% (139 Mmboe) of the Planning Area energy endowment (29,041 Mmboe). The overall assessment results for play 17 are shown in table 1. Oil and gas-condensate liquids form 57% of the hydrocarbon energy endowment of play 17. Table 5 reports the detailed assessment results by commodity for play 17.

Table 3 summarizes the volumetric input data developed for the *GRASP* computer model of Chukchi Sea play 17. Table 4 reports the risk model used for play 17. The location of play 17 is shown in figure 1.

This play addresses the unstructured area of the Arctic platform that lies south of Barrow arch, east of the wrench fault province of western Chukchi shelf (equivalent play 12), and north of the fold-belt (play 11). Potential reservoirs are turbidite sandstones within the Lower Cretaceous Torok Formation. Exploratory drilling at Diamond and Burger prospects has shown that sandstone is quite sparse within the Torok Formation in this play. Reservoir presence is therefore one important risk element for the play. Low-relief anticlines (possibly related to compaction), mounded fan complexes, and slope turbidites (isolated within slope shales) form the primary anticipated trap types, few of which are readily observable in seismic data. All of the "unidentified" prospects used to construct the prospect numbers distribution for this play were estimated using a prospect density (area basis) that was devised from mapping "geobodies" imaged by seismic attributes in three-dimensional seismic data within the correlative sequence in the National Petroleum Reserve-Alaska (NPRA). The size range of these "geobodies" also helped define the prospect area distribution. The play is modeled as predominately charged by the Hanna trough play charging system, although some contribution from the gas-prone Colville

basin system is also possible, particularly in southern parts of the play area. The play was tested by Burger and Diamond wells, the latter noting minor oil shows. Peard and Tunalik wells encountered abundant gas shows in turbiditic sandstones of the Torok Formation.

Play 17, Torok Turbidites (Lower Brookian)-Arctic Platform, Chukchi Sea OCS Planning Area, 2006 Assessment, Conditional BOE Sizes of Ten Largest Pools			
Assessment Results as of November 2005			
Pool Rank	BOE Resources *		
	F95	Mean	F05
1	6	65	210
2	3	32	83
3	2.2	23	60
4	1.8	18	50
5	1.6	15	43
6	1.4	13	37
7	1.3	12	34
8	1.2	11	31
9	1.14	10.2	29
10	1.08	9.6	27
* Conditional, Technically-Recoverable, Millions of Barrels Energy-Equivalent (Mmboe), from "PSRK.out" file			
F95 = 95% chance that resources will equal or exceed the given quantity			
F05 = 5% chance that resources will equal or exceed the given quantity			
BOE = total hydrocarbon energy, expressed in barrels-of-oil-equivalent, where 1 barrel of oil = 5,620 cubic feet of natural gas			

Table 2

A maximum of 367 hypothetical pools is forecast by the aggregation of the risk model and the prospect numbers model for play 17. These 367 pools range in mean conditional (un-risked) recoverable volumes from 0.2 Mmboe (pool rank 367) to 65 Mmboe (pool rank 1). Pool rank 1 ranges in possible conditional recoverable volumes from 6 Mmboe (F95) to 210 Mmboe (F05). Table 2 shows the conditional sizes of the 10 largest pools in play 17.

In the computer simulation for play 17 a total of 88,399 "simulation pools" were sampled for size. These simulation pools can be grouped according to the USGS size class system in which sizes double with each successive class. Pool size class 9 contains the largest share (18,493, or 21%) of simulation pools (conditional, technically recoverable BOE resources) for play 17. Pool size class 9 ranges from 8 to 16 Mmboe. The largest 14 simulation pools for play 17 fall within pool size class 15, which ranges in size from 512 to 1,024 Mmboe. Table 6 reports statistics for the simulation pools developed in the GRASP computer model for play 17.

GRASP Play Data Form (Minerals Management Service-Alaska Regional Office)

Basin: Chukchi Sea Planning Area
Play Number: 17
Play UAI Number: AAAAA DAR

Assessor: K.W. Sherwood
Play Name: Torok Turbidites (Lower Brookian) - Arctic Platform

Date: January 2005

Play Area: mi² (million acres) 15,837 (10.136)
Reservoir Thermal Maturity: % Ro 0.80 - 0.85

Play Depth Range: feet 4,500 - 10,000 (mean = 8,500)
Expected Oil Gravity: ° API 30
Play Water Depth Range: feet 150 - 170 (mean = 160)

POOLS Module (Volumes of Pools, Acre-Feet)

Fractile	F100	F95	F90	F75	F50	Mean/Std. Dev.	F25	F15	F10	F05	F02	F01	F00
Prospect Area (acres)-Model Input*	125		304		1284	2418/3856			5429				22809
Prospect Area (acres)-Model Output**	125	240	340	627	1329	2357/2882	2815	4278	5606	8136			22256
Fill Fraction (Fraction of Area Filled)	0.25	0.37	0.40	0.44	0.50	0.51/0.09	0.57	0.61	0.63	0.68			1.00
Productive Area of Pool (acres)***	48	116	169	313	666	1199/1504	1443	2124	2869	4244	5300	6100	15138
Pay Thickness (feet)	30	62	69	82	100	104/30	121	135	144	160	180	195	350

* model fit to prospect area data in *BESTFIT*
** output from *@RISK* after aggregation with fill fraction
*** from *@RISK* aggregation of probability distributions for prospect area and fill fraction

MPRO Module (Numbers of Pools)

Input Play Level Chance	0.3
Output Play Level Chance*	0.291

Prospect Level Chance	0.1092

Exploration Chance	0.03276

* First Occurrence of Non Zero Pools As Reported in PSUM Module

Risk Model	Play Chance	Petroleum System Factors	Prospect Chance
		Trap Presence (inferred from geobody sizes and densities in NPRA 3D seismic amplittude mapping)	0.4
	0.3	Reservoir Presence (thin turbidite sequence)	
		Chance Porosity > 10%	0.42
		Migration (must migrate along underlying unconformities with sparse, discontinuous aquifers)	0.65

Fractile	F99	F95	F90	F75	F50	Mean/Std. Dev.	F25	F15	F10	F05	F02	F01	F00
Numbers of Prospects in Play	7	15	20	36	69	119.88/212.36	130	180	230	320	500	600	3100
Numbers of Pools in Play						3.93/14.15	3	8	12	19	32	46	367

Zero Pools at F29.13

Minimum Number of Pools	3 (F25)

Mean Number of Pools	3.93

Maximum Number of Pools	367

POOLS/PSRK/PSUM Modules (Play Resources)

Fractile	F100	F95	F90	F75	F50	Mean/Std. Dev.	F25	F15	F10	F05	F02	F01	F00
Oil Recovery Factor (bbl/acre-foot)	18	37	42	55	77	90/52	111	135	154	193	230	270	654
Gas Recovery Factor (Mcfg/acre-foot)	175	322	354	426	541	589/228	700	810	898	1023	1300	1400	2024
Gas Oil Ratio (Sol'n Gas)(cf/bbl)	480	940	1000	1120	1240	1237/212	1370	1440	1490	1560	1640	1690	2000
Condensate Yield ((bbl/Mmcfg)	13	29	33	40	50	54/19	64	72	79	90	105	120	200

Pool Size Distribution Statistics from *POOLS* (1,000 BOE):	μ (mu)= 8.945	σ² (sigma squared)= 1.458	Random Number Generator Seed= 761819

BOE Conversion Factor (cf/bbl)	5620
Probability Any Pool is 100% Oil	0.2
Probability Any Pool is 100% Gas	0.2

Probability Any Pool Contains Both Oil and Free Gas (Gas Cap)	0.6
Fraction of Pool Volume Gas-Bearing in Oil Pools with Gas Cap	0.3

Table 3. Input data for Chukchi Sea play 17, 2006 assessment.

Risk Analysis Form - 2006 National Assessment

Assessment Province: Chukchi Sea OCS Planning Area	**Play Number, Name:** 17. Torok Turbidites (Lower Brookian) - Arctic Platform
Assessor(s): K.W. Sherwood	**Play UAI:** AAAAA DAR
Date: 1-Jan-05	

For each component, a *quantitative* probability of success (i.e., between zero and one, where zero indicates no confidence and one indicates absolute certainty) based on consideration of the *qualitative* assessment of **ALL** elements within the component was assigned. This is the assessment of the probability that the minimum geologic parameter assumptions have been met or exceeded.

		Play Chance Factors	**Averge Conditional Prospect Chance[1]**
1. Hydrocarbon Fill component (1a * 1b * 1c)	**1**	*1.0000*	*0.6500*
a. Presence of a Quality, Effective, Mature Source Rock			
Probability of efficient source rock in terms of the existence of sufficient volume of mature source rock of adequate quality located in the drainage area of the reservoirs.	1a	1.00	1.00
b. Effective Expulsion and Migration			
Probability of effective expulsion and migration of hydrocarbons from the source rock to the reservoirs.	1b	1.00	0.65
c. Preservation			
Probability of effective retention of hydrocarbons in the prospects after accumulation.	1c	1.00	1.00
2. Reservoir component (2a * 2b)	**2**	*0.3000*	*0.4200*
a. Presence of reservoir facies			
Probability of presence of reservoir facies with a minimum net thickness and net/gross ratio (as specified in the resource assessment).	2a	0.30	1.00
b. Reservoir quality			
Probability of effectiveness of the reservoir, with respect to minimum effective porosity, and permeability (as specified in the resource assessment).	2b	1.00	0.42
3. Trap component (3a * 3b)	**3**	*1.0000*	*0.4000*
a. Presence of trap			
Probability of presence of the trap with a minimum rock volume (as specified in the resource assessment).	3a	1.00	0.40
b. Effective seal mechanism			
Probability of effective seal mechanism for the trap.	3b	1.00	1.00
Overall Play Chance (Marginal Probability of hydrocarbons, MPhc) (1 * 2 * 3) *Product of All Subjective Play Chance Factors*		*0.3000*	
Average Conditional Prospect Chance[1] (1 * 2 * 3) *Product of All Subjective Conditional Prospect Chance Factors*			*0.1092*
[1] ***Assumes that the Play exists (where all play chance factors = 1.0)*** *Must be consistent with play chance and prospect distribution -- See discussion on Page 3 of Guide*			
Exploration Chance *(Product of Overall Play Chance and Average Conditional Prospect Chance)*		*0.0328*	

Comments: *See guidance document for explanation of the Risk Analysis Form*

2b: Chance That Porosity >10%, Based on Regional Model for Porosity vs Reservoir Thermal Maturity

Table 4. Risk model for Chukchi Sea play 17, 2006 assessment.

GRASP - Geologic and Economic Resource Assessment Model - PSUM Module Results
Minerals Management Service - Alaska OCS Region
GRASP Model Version: 8.29.2005)
Computes the Geologic Resource Potential of the Play

Play UAI: AAAAADAR			**Play No.**		**17**	
World	Level	-	World	Level	Resources	
Country	Level	-	UNITED	STATES	OF	AMERICA
Region	Level	-	MMS	-	ALASKA	REGION
Basin	Level	-	**CHUKCHI**	**SEA**	**SHELF**	
Play	**Level**	**-**	**Play**		**17 Torok Turbidtes (Lower Brookian)**	
Geologist	Kirk	W.	Sherwood		**- Arctic Platform**	
Remarks		2005 Assessment				
Run Date & Time:		Date	19-Sep-05 Time		13:55:25	

Summary of Play Potential

Product	MEAN	Standard Deviation
BOE (Mboe)	138,880	633,000
Oil (Mbo)	64,969	298,920
Condensate (Mbc)	13,867	63,296
Free (Gas Cap & Nonassociated) Gas (Mmcfg)	256,900	1,172,300
Solution Gas (Mmcfg)	80,578	370,820

    10000 (Number of Trials in Sample)
    0.291 (MPhc [Probability] of First Occurrence of Non-Zero Resource)
    Windowing Feature: used

Empirical Probability Distributions of the Products

Greater Than Percentage	BOE (Mboe)	Oil (Mbo)	Condensate (Mbc)	Free (Gas Cap & Nonassociated) Gas (Mmcfg)	Solution Gas (Mmcfg)
100	0	0	0	0	0
99.99	0	0	0	0	0
99	0	0	0	0	0
95	0	0	0	0	0
90	0	0	0	0	0
85	0	0	0	0	0
80	0	0	0	0	0
75	0	0	0	0	0
70	0	0	0	0	0
65	0	0	0	0	0
60	0	0	0	0	0
55	0	0	0	0	0
50	0	0	0	0	0
45	0	0	0	0	0
40	0	0	0	0	0
35	0	0	0	0	0
30	0	0	0	0	0
25	26,578	12,318	2,637	50,179	15,141
20	62,128	29,150	6,112	114,840	36,144
15	112,740	51,859	11,371	214,630	63,618
10	184,730	87,548	17,744	339,170	107,270
8	228,710	105,400	23,452	428,960	132,250
6	294,640	138,120	29,651	541,990	171,010
5	337,890	149,790	37,642	658,110	187,500
4	434,330	198,850	45,359	823,530	244,980
2	2,579,900	1,198,000	260,660	4,810,700	1,490,400
1	4,186,300	1,964,200	416,940	7,712,300	2,432,900
0.1	5,985,800	2,557,400	669,190	12,170,000	3,336,900
0.01	6,806,900	2,903,600	815,910	13,798,000	3,553,100
0.001	6,907,600	3,063,000	731,560	13,693,000	3,801,900

Table 5. Assessment results by commodity for Chukchi Sea play 17, 2006 assessment.

Basin: CHUKCHI SEA SHELF
Play 17 - L. Brookian - Torok-Arctic Platform
UAI Key: AAAAADAR

Model Simulation "Pools" Reported by "Fieldsize.out" *GRASP* Module

Class	Min (MMBOE)	Max (MMBOE)	Pool Count	Percentage	Trial Average	Trials w/Pool Avg	Mixed Pool	Oil Pool	Gas Pool	Mixed Min	Mixed Max	Oil Min	Oil Max	Gas Min	Gas Max	Total Min	Total Max	Resource Min	Resource Max	Total Resource	Average Resource
1	0.0312	0.0625	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000000	0.000000	0.000000	0.000000
2	0.0625	0.125	5	0.005656	0.0005	0.001718	1	4	0	1	1	1	1	0	0	1	1	0.078282	0.124295	0.525680	105.136022
3	0.125	0.25	100	0.113123	0.01	0.034352	41	46	13	1	2	1	2	1	1	1	4	0.140402	0.248176	20.944899	209.448993
4	0.25	0.5	789	0.892544	0.0789	0.271041	428	258	103	1	6	1	5	1	3	1	8	0.250117	0.499997	317.644442	402.591169
5	0.5	1	3247	3.673119	0.3247	1.115424	1852	825	570	1	14	1	7	1	5	1	19	0.500008	0.999901	2488.780000	766.485810
6	1	2	8028	9.081551	0.8028	2.757815	4763	1897	1368	1	28	1	19	1	10	1	51	1.000075	1.999783	12130.150000	1.510980
7	2	4	14508	16.411951	1.4508	4.983854	8827	2996	2685	1	49	1	20	1	16	1	75	2.000008	3.999971	42573.322000	2.934472
8	4	8	18450	20.871277	1.845	6.338028	11150	3761	3539	1	59	1	24	1	21	1	83	4.000315	7.999819	106950.084000	5.796752
9	8	16	18493	20.91992	1.8493	6.3528	11180	3549	3764	1	55	1	21	1	23	1	88	8.000018	15.999960	211645.964000	11.444653
10	16	32	13709	15.508094	1.3709	4.709378	8310	2465	2934	1	45	1	16	1	19	1	69	16.000800	31.999381	307063.761000	22.398699
11	32	64	7638	8.640369	0.7638	2.623841	4517	1298	1823	1	26	1	10	1	13	1	39	32.001181	63.975567	337184.082000	44.145599
12	64	128	2756	3.117682	0.2756	0.946754	1609	442	705	1	15	1	5	1	9	1	19	64.002401	127.999223	235118.698000	85.311577
13	128	256	580	0.656116	0.058	0.199244	328	93	159	1	5	1	3	1	4	1	7	128.385982	255.060476	98626.106000	170.045013
14	256	512	82	0.092761	0.0082	0.028169	43	18	21	1	3	1	1	1	1	1	3	258.604086	473.382378	25906.720000	315.935608
15	512	1024	14	0.015837	0.0014	0.004809	5	9	0	1	1	1	2	0	0	1	2	516.213766	1017.604000	8814.881000	629.634338
16	1024	2048	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000000	0.000000	0.000000	0.000000
17	2048	4096	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000000	0.000000	0.000000	0.000000
18	4096	8192	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000000	0.000000	0.000000	0.000000
19	8192	16384	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000000	0.000000	0.000000	0.000000
20	16384	32768	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000000	0.000000	0.000000	0.000000
21	32768	65536	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000000	0.000000	0.000000	0.000000
22	65536	131072	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000000	0.000000	0.000000	0.000000
23	131072	262144	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000000	0.000000	0.000000	0.000000
24	262144	524288	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000000	0.000000	0.000000	0.000000
25	524288	1048576	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000000	0.000000	0.000000	0.000000
Not Classified			0	0	0	0	Below Class 0	0	0									Below Class 0.000000	0.000000	0.000000	0.000000
Totals			88399	99.999992	8.8399	30.367228	Above Class 0	0	0									Above Class 0.000000	0.000000	0.000000	0.000000

Min and Max refer to numbers of pools of the relevant size class that occur within any single trial in the simulation.

Min and Max refer to aggregate resources of the relevant size class that occur within any single trial in the simulation.

Number of Pools not Classified: 0
Number of Pools below Class 1: 0
Number of Trials with Pools: 2911

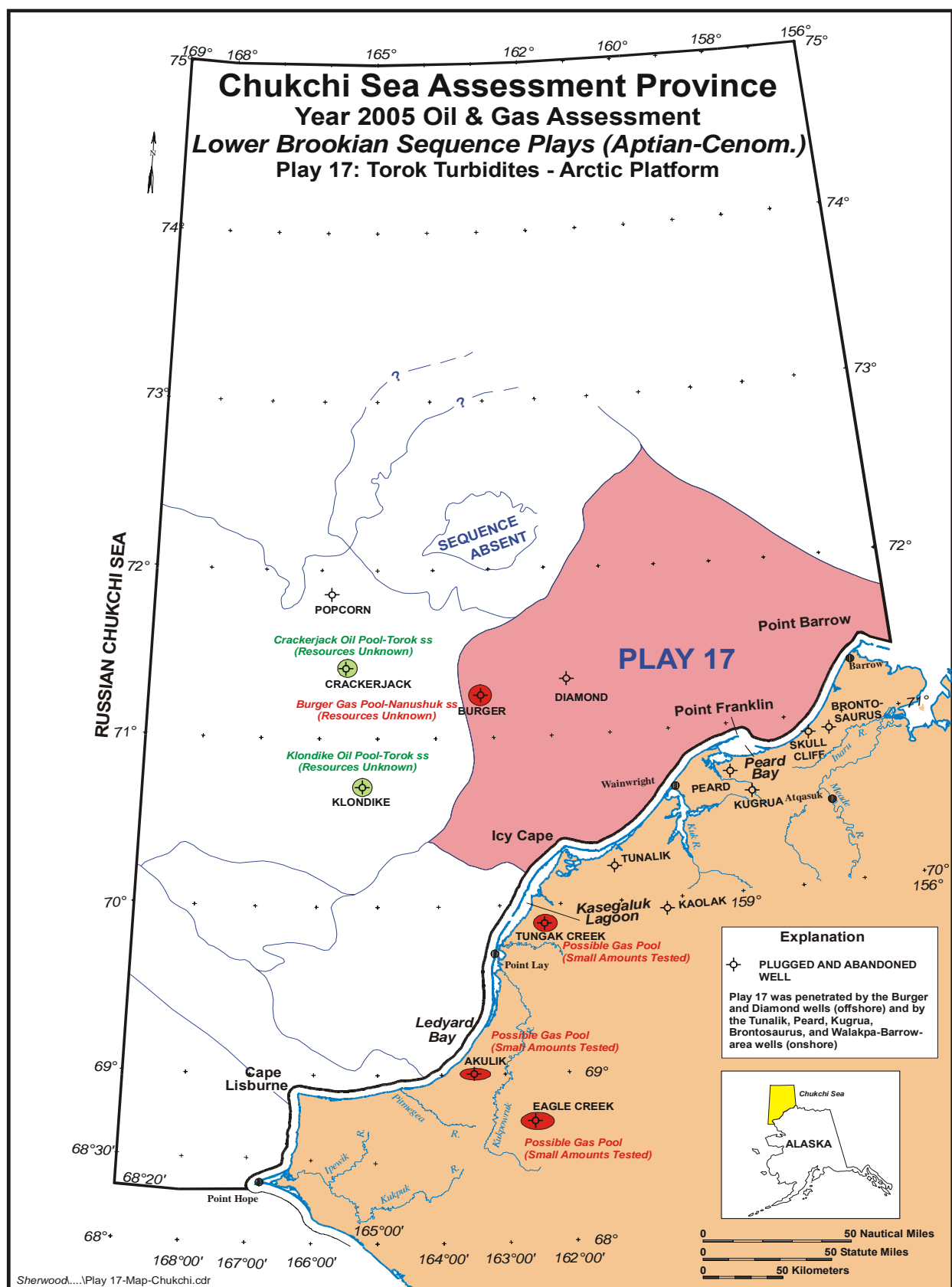**Table 6**. Statistics for simulation pools created in computer sampling run for Chukchi Sea play 17, 2006 assessment.

Figure 1. Map location of Chukchi Sea play 17, 2006 assessment.