ALASKA FEDERAL OFFSHORE
Descriptions of Geologic Plays
1995 National Resource Assessment
U.S. Minerals Management Service

NAVARIN BASIN ASSESSMENT PROVINCE
(Dorothy MacLean, Steve Haley, John Larson)

Seven plays based on a facies-cycle wedge model (White, 1980) have been identified in the Navarin basin assessment province. In the facies-cycle wedge model, the base of a wedge is made up of a succession of facies deposited during a marine transgression. The middle of the wedge represents the peak of the transgression, and the top of the wedge represents a subsequent marine regression.

The plays proposed for Navarin basin include: 1) Miocene transgressive shelf sands (wedge base); 2) regressive shelf sands (wedge top); 3) Oligocene tectonic sands (wedge middle); 4) turbidite and submarine fan sands (wedge middle); 5) Eocene transgressive shelf sands (wedge base); 6) subunconformity nonmarine and marginal marine sands (subunconformity); and 7) Paleocene marine sands (apparent wedge top).

Play 1 (UANA0100[1]). Miocene Transgressive Shelf Sands (wedge base): Data from the COST No.1 well indicate that during the early Miocene a basin-wide regression ended and a basin-wide transgression began. The basin subsided slowly at a nearly constant rate through the late Miocene. Local basin highs previously exposed to wave-base erosion were inundated. The postulated regional sediment source terrane consisted of a low-lying borderland drained by sluggish streams. The reservoir sand for the play was derived from newly eroded and reworked volcaniclastic sediments transported into a shelf-wide depositional system (outer to inner neritic). It is probable that at the marine margin a limited supply of sand and an abundant supply of mud existed. A transgressive event under these conditions may have led to the deposition of a discontinuous series of beach sands that impinged on the unconformity and wedged out basin-ward, forming the play 1 reservoir. This play extends from the lower to the upper Miocene, and is located around the edge of the Navarin basin.

Play 2 (UANA0200). Regressive Shelf Sands (wedge top): Data from the Navarin COST

[1]*The "UA" Code is the "Unique Assessment Identifier" for each play, and is the principal guide to GRASP data files.*

No.1 well indicate that a basin-wide regression began during the late Oligocene and culminated during the early Miocene. The regression was due to a sea level drop; no major tectonic uplift occurred during this time period.

During the gradual emergence (marine regression), sand deposits that came to be exposed above sea level were eroded and redeposited seaward. This process continued throughout the regression, leaving the remaining accumulation of sand at the lowest stand of the sea. The typical regressive marginal marine beach or bar sand bodies that resulted probably had a very limited width but often may have had a linear extent of many miles. These conditions, along with structural control (faults and folds) on the Navarin basin depositional surface, and in combination with longshore drift, may have both trapped and concentrated local accumulations of sand and elsewhere locally inhibited sand deposition in the play 2 sequence. The largest sand bodies in the play probably coincide with large post- or synsedimentary structures.

Play 2 includes the best reservoir sands found in the 9 wells drilled in the basin. Over 200 feet of good reservoir sands with porosities of 15 to 20 percent were found in the COST No.1 well. These occur in five beds ranging in thickness from 21 to 100 feet (Turner and others, 1984). This play extends from the upper Oligocene to the lower Miocene and is located around the edge of Navarin basin.

Play 3 (UANA0300). Oligocene Tectonic Sands (wedge middle): Tectonic subsidence beginning in the early to middle Eocene caused a basin-wide marine transgression. In the vicinity of the COST No.1 well this subsidence was temporarily interrupted by two local tectonic uplifts: one lasting from late Eocene through earliest Oligocene and the other during the early Oligocene. Other such local events may have occurred at different locations and at different times in the basin during this interval (late Eocene to late Oligocene). Highs formed during up-warping were eroded, and the resulting sediments sorted and redeposited. Sand deposits exposed above sea level were probably eroded and redeposited seaward, leaving the largest accumulations of sand in the play 3 sequence at the low sea-stand margin. This play extends from the upper Eocene to the upper Oligocene, and is located around the edge of the Navarin basin.

Play 4 (UANA0400). Turbidite and Submarine Fan Sands (wedge middle): The centers of the subbasins remained submerged during most or all of the Tertiary, and it is probable that turbidity currents deposited sand in them. In addition to evidence for such turbidites seen on Navarin basin seismic sections, coarse-grained materials, including conglomerates, were dredged from Eocene to early Oligocene rocks on the continental slope. Studies of other strike-slip basins (Hornelen basin, Norway; Little Sulphur Creek and Ridge basins, California) also support this hypothesis. Play 4 extends from the upper Eocene to the lower Miocene, and is found mainly in the centers of the subbasins.

Play 5 (UANA0500). Eocene Transgressive Shelf Sands: The reservoir sands for this play were deposited as a result of a basin-wide transgression lasting from the middle Eocene to the late Eocene or early Oligocene. An abundant supply of mud and a limited supply of sand probably lead to the deposition of a series of beach sands that impinged on the unconformity and wedged out basinward. Sand supply was probably insufficient to form a continuous blanket over the unconformity. Sand bodies may have formed around local highs. The vertical extent of play 5 is from the middle or upper Eocene to possibly as high as the lower Oligocene. Most of the Navarin basin is included in the play area.

Play 6 (Not Quantified). Nonmarine and Marginal Marine Sands (subunconformity): A regression during the Late Cretaceous led to the deposition of nonmarine and marginal marine sands. At the OCS Y-0599 well these sands were deposited beginning in the Maastrichtian and possibly continuously into Eocene time. At other well locations the nonmarine sands appear to be confined to the Paleocene to early Eocene. The distribution of these nonmarine and marginal marine facies is unknown, and no source rock has been identified. This play was not evaluated because of an extremely low play chance.

Play 7 (Not Quantified). Paleocene Marine Sands (apparent wedge top): Data from the OCS Y-0673 well indicate that marine sands were deposited in parts of the basin during the Paleocene. However, the distribution of this facies is unknown, and no source rock was identified. This play was not evaluated because of an extremely low play chance.

OIL AND GAS ENDOWMENTS OF NAVARIN BASIN PLAYS

Risked, Undiscovered, Conventionally Recoverable Oil and Gas

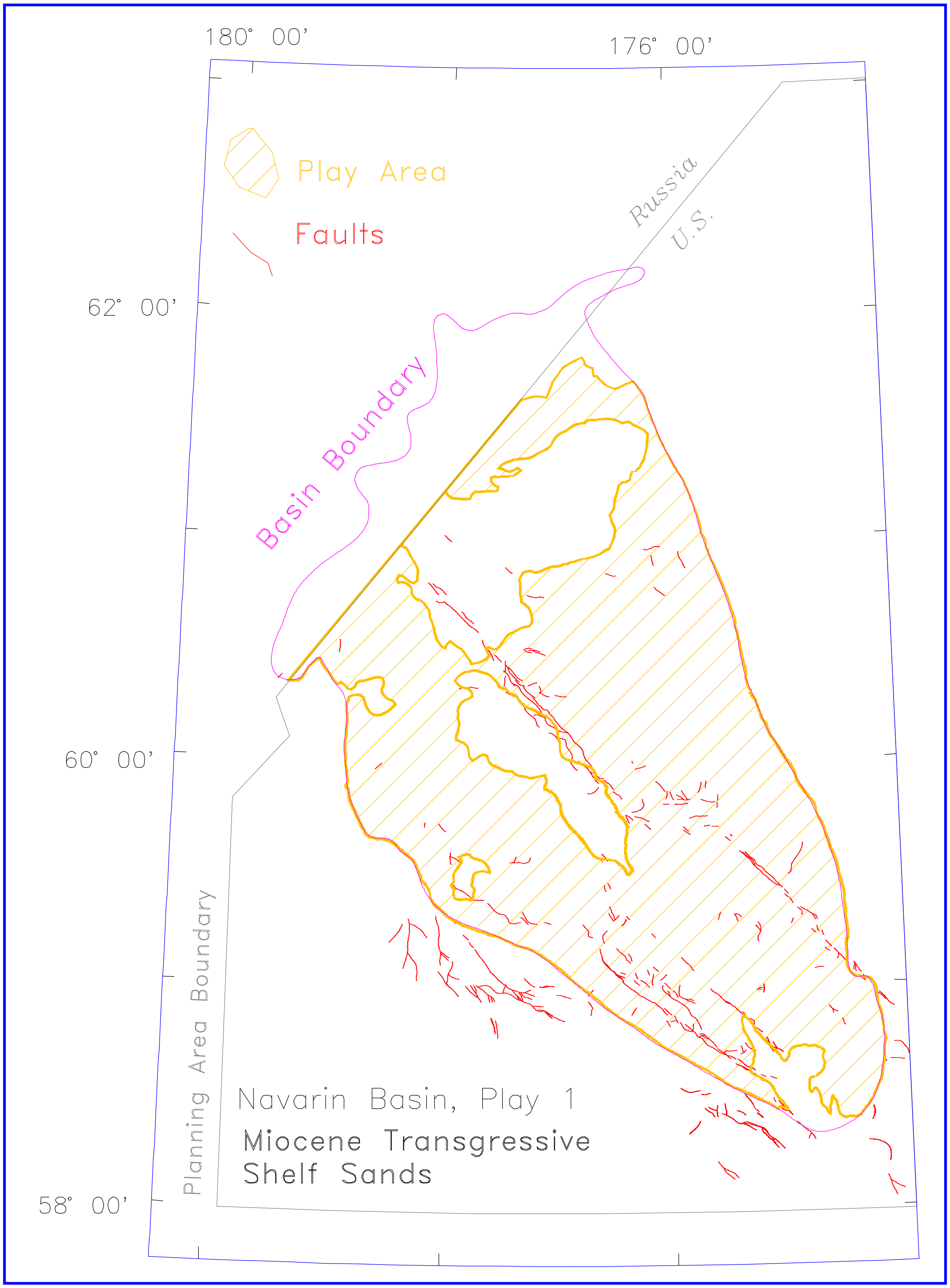
PLAY NO.	PLAY NAME (UAI * CODE)	OIL (BBO)			GAS (TCFG)		
		F95	MEAN	F05	F95	MEAN	F05
1.	Miocene Transgressive Shelf Sands (UANA0100)	0.000	0.078	0.206	0.000	0.666	1.951
2.	Regressive Shelf Sands (UANA0200)	0.000	0.272	0.605	0.000	2.432	5.655
3.	Oligocene Tectonic Sands (UANA0300)	0.000	0.020	0.054	0.000	0.196	0.599
4.	Turbidite and Submarine Fan Sands (UANA0400)	0.000	0.116	0.275	0.000	2.518	6.236
5.	Eocene Transgressive Shelf Sands (UANA0500)	0.000	0.011	0.036	0.000	0.335	1.024
	FASPAG AGGREGATION	***0.000***	***0.496***	***1.214***	***0.000***	***6.147***	***18.176***

* *Unique Assessment Identifier, code unique to play.*

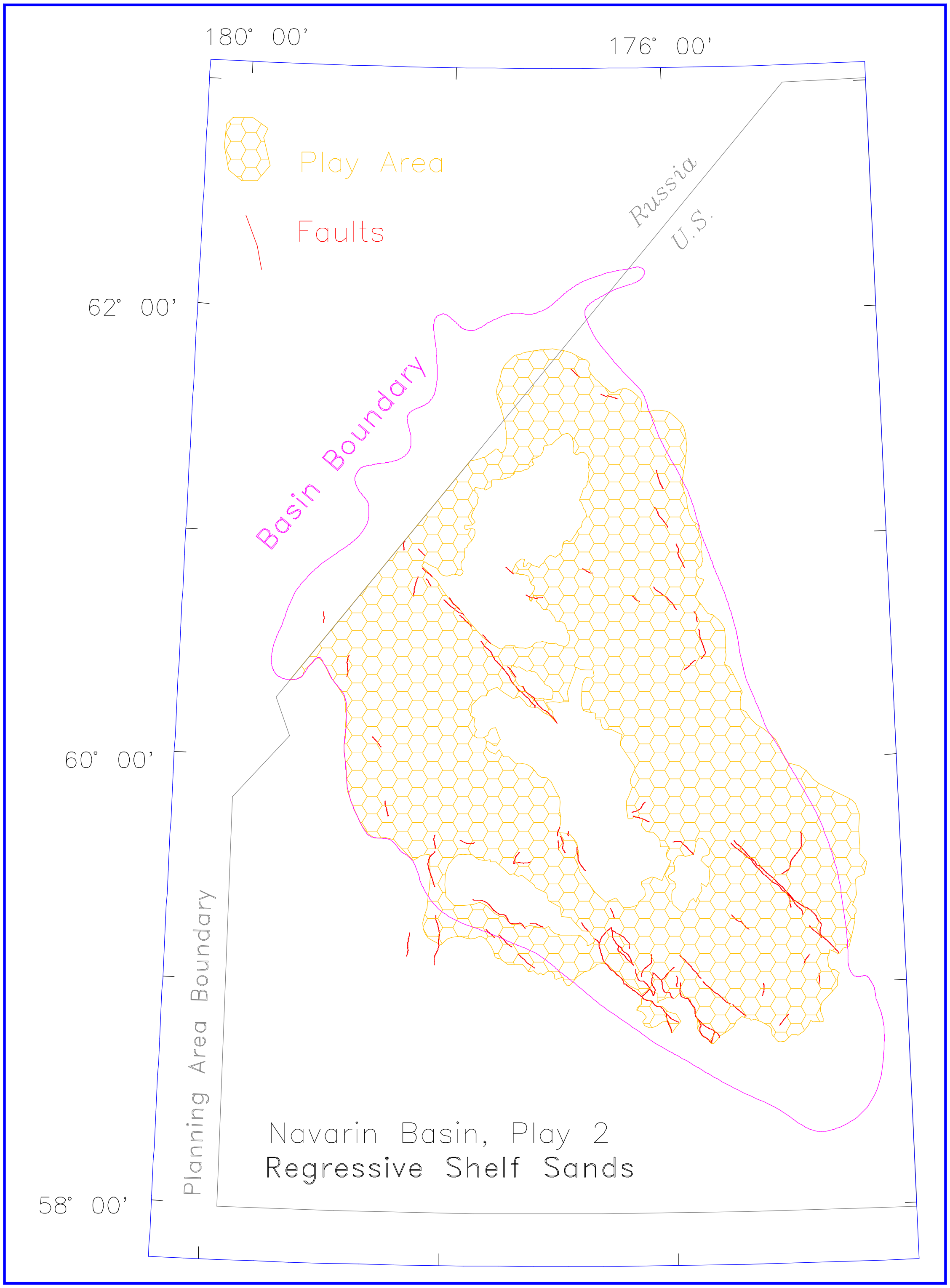
REFERENCES CITED

Turner, R.F., McCarthy, C.M., Steffy, D.A., Lynch, M.B., Martin, G.C., Sherwood, K.W., Flett, T.O., and Adams, A.J., 1984, Geological and operational summary, Navarin Basin COST No. 1 well, Bering Sea, Alaska: Turner, R.F., ed., U.S. Minerals Management Service, Alaska OCS Region, OCS Report MMS 84-0031, 245 p.

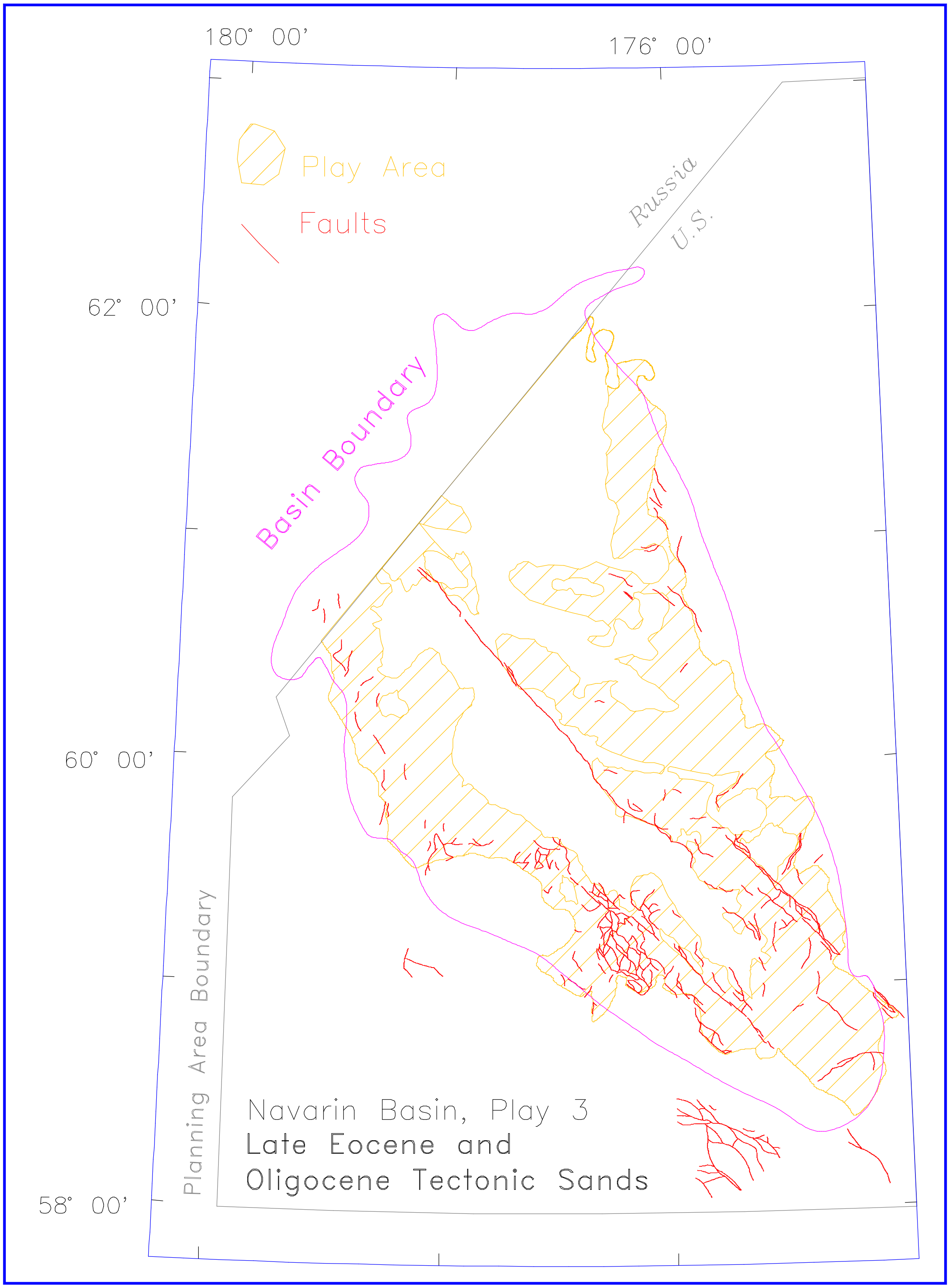
NAVARIN BASIN - MAP OF PLAY 1
MIOCENE TRANSGRESSIVE SHELF SANDS



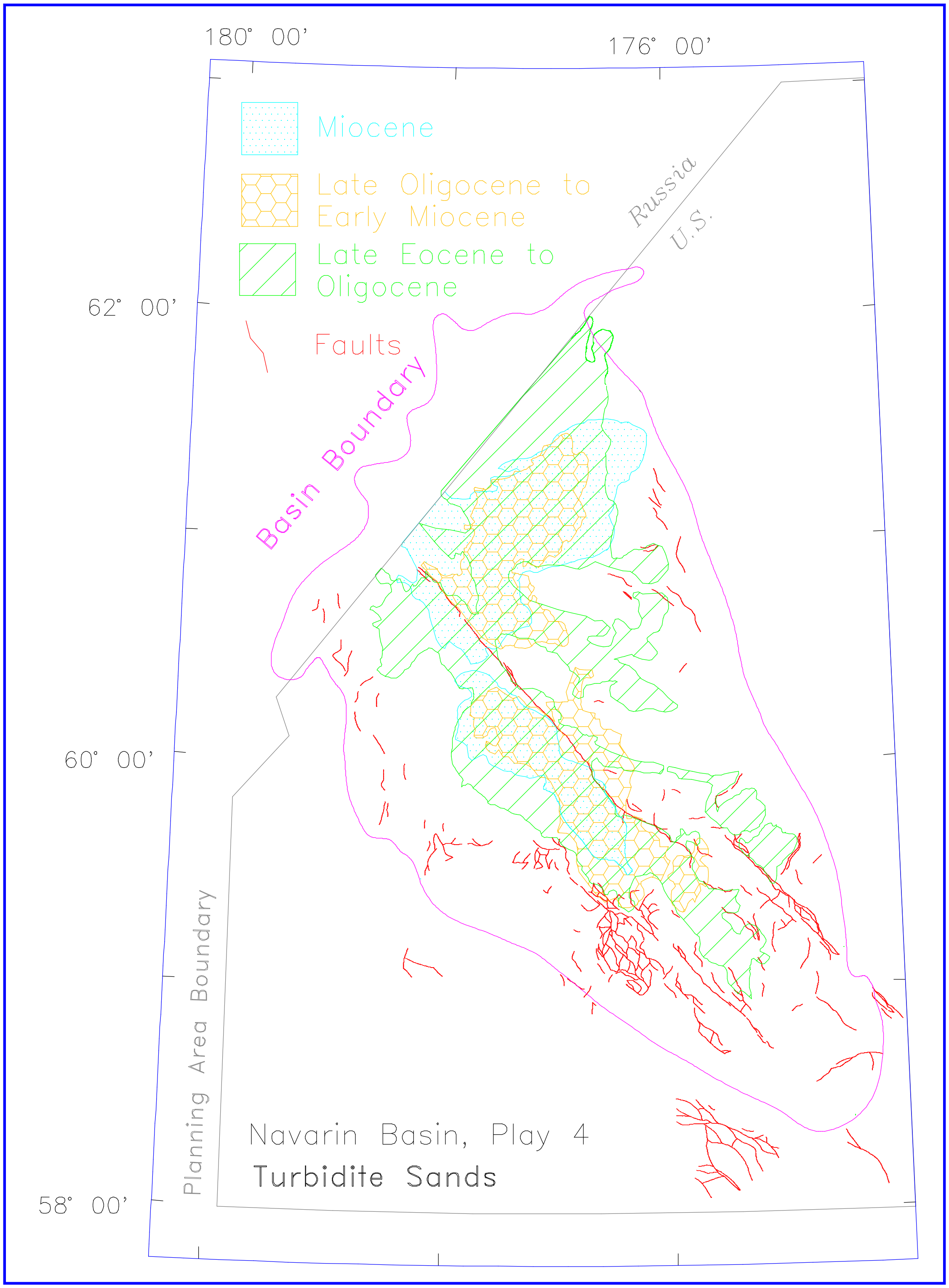
NAVARIN BASIN - MAP OF PLAY 2
REGRESSIVE SHELF SANDS



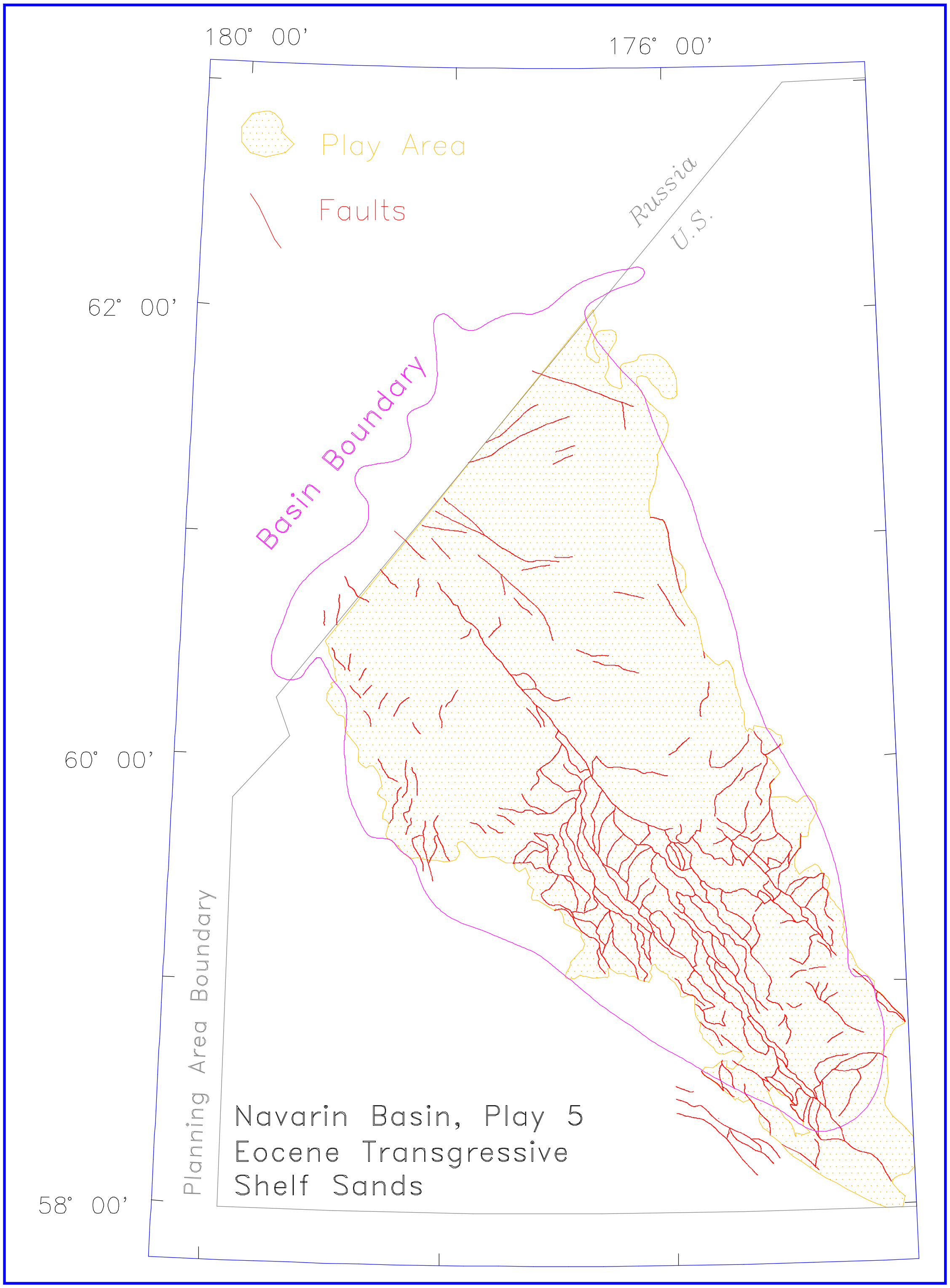
NAVARIN BASIN - MAP OF PLAY 3
LATE EOCENE AND OLIGOCENE TECTONIC SANDS



NAVARIN BASIN - MAP OF PLAY 4
TURBIDITE AND SUBMARINE FAN SANDS



NAVARIN BASIN - MAP OF PLAY 5
EOCENE TRANSGRESSIVE SHELF SANDS



EXPLANATION OF DATA TABLES FOR NAVARIN BASIN ASSESSMENT PROVINCE

RESULTS

LOG-N PARAMS (PORE)	Key mathematic parameters that describe log-normal probability distributions for volume of hydrocarbon-bearing rock, in acre-feet, for each play as reported in the **PORE** module of **GRASP**.
mu	Natural logarithm of F50 value of log-normal distribution for volume of hydrocarbon-bearing rock, or "μ", for the subject play. **mu** = ln F50. [Note: distribution **mean** = $e^{(mu + 0.5[sig. sq.])}$.]
sig. sq.	The variance of the log-normal distribution for volume of hydrocarbon-bearing rock, or "σ^2", for the subject play. **sig. sq.** = $\{\ln [0.5((F50/F16)+(F84/F50))]\}^2$.
N (MPRO)	Number of hydrocarbon pools calculated for the plays by the **MPRO** module of **GRASP** from inputs for probability distributions of prospect numbers and geologic chances of success (approximately the product of play and prospect chances of success) . The maximum (**Max**) number of pools for each play was entered into the **MONTE1** module of **GRASP** to fix the number of pools aggregated to calculate play resources.
Reserves	Sums of recoverable oil and gas volumes for pools within the play, including both proven and inferred reserve categories. A "prop" entry indicates that the reserve data are proprietary.
BCF	Billions of cubic feet of gas, recoverable, at standard (surface) conditions (here fixed at a temperature of 60° Fahrenheit or 520° Rankine, and 14.73 psi atmospheric pressure).
MMB	Millions of barrels of oil, recoverable, at standard (surface) conditions.
Undiscovered Potential	Risked, undiscovered, conventionally recoverable oil and gas resources of the play, here reported at **Means** of probability distributions.

EXPLANATION OF DATA TABLES FOR NAVARIN BASIN ASSESSMENT PROVINCE

Mean Pool Sizes of Ranks 1 to 3	Unrisked (or conditional) mean volumes of recoverable oil and gas in the three largest pools in the play.

PLAY INPUT DATA

F100.....F00	Fractiles for values within probability distributions entered to **GRASP** for calculations of play resources. Four-point distributions (F100, F50, F02, F00) generally indicate that calculations were conducted using log-normal mathematics. Eight-point distributions generally indicate that calculations were conducted using Monte Carlo mathematics. Choice of mathematic approach was in most cases the option of the assessor.
Prospect Area	Maximum area of prospect closure, or area within spill contour, in acres. Probability distributions for prospect areas were generally based on distributions assembled independently for each play from large numbers of prospects mapped with seismic reflection data.
Trap Fill	Trap fill fraction, or fraction of prospect area in which the reservoir is predicted to be saturated by hydrocarbons.
Pool Area	Areal extent of hydrocarbon-saturated part of prospect, in acres. Calculated using **PRASS**, or **SAMPLER** module of **GRASP**, to integrate input probability distributions for prospect areas and trap fill fractions.
Pay Thickness	Thickness of hydrocarbon-productive part of reservoir within pool areas, in feet. Probability distributions for prospect areas, trap fill fractions, and pay thicknesses are integrated in the **PORE** module of **GRASP**, to calculate a probability distribution for volume of hydrocarbon-bearing rock, in feet, within the play as reported above under **LOG-N PARAMS (PORE)** .

EXPLANATION OF DATA TABLES FOR NAVARIN BASIN ASSESSMENT PROVINCE

Oil Yield (Recov. B/Acre-Feet)	Oil, in barrels at standard (surface) conditions, recoverable from a volume of one acre-foot of oil-saturated reservoir in the subsurface. Oil yield probability distributions were generally calculated in a separate exercise using **PRASS** to integrate input probability distributions for porosities, oil saturations, oil shrinkage factors (or "Formation Volume Factors"), and oil recovery efficiencies.
Gas Yield (MMCF/Ac.-Ft.)	Gas, in millions of cubic feet at standard (surface) conditions, recoverable from a volume of one acre-foot of gas-saturated reservoir in the subsurface. Distributions were generally calculated in a separate exercise using **PRASS** to integrate input probability distributions for porosities, gas saturations, reservoir pressures, reservoir temperatures (in degrees Rankine), gas deviation ("Z") factors, combustible fractions (that exclude noncombustibles such as carbon dioxide, nitrogen, etc.), and gas recovery efficiencies.
Solution Gas-Oil Ratio (CF/B)	Quantity of gas dissolved in oil in the reservoir that separates from the oil when brought to standard (surface) conditions, in cubic feet recovered per barrel of produced oil.
Gas Cond. (B/MMCF)	Quantity of liquids or condensate dissolved in gas in the reservoir that separates from the gas when brought to standard (surface) conditions, in barrels recovered per million cubic feet of produced gas.
Number of Prospects.......	Probability distributions for numbers of prospects in plays, generally ranging from minimum values (F99) representing the numbers of mapped prospects, to maximum values (F00) that include speculative estimates for the numbers of additional prospects that remain unidentified (generally stratigraphic prospects, geophysically indefinite prospects, or prospects expected in areas with no seismic coverage).

EXPLANATION OF DATA TABLES FOR NAVARIN BASIN ASSESSMENT PROVINCE

Probabilities for Oil, Gas, or Mixed Pools

Oil (OPROB) — Fraction of hydrocarbon pools that consist entirely of oil, with no free gas present. Typically, an undersaturated oil pool.

Gas (GPROB) — Fraction of hydrocarbon pools consisting entirely of gas, with no free oil present.

Mixed (MXPROB) — Fraction of hydrocarbon pools that contain both oil and gas as free phases, the gas usually present as a gas cap overlying the oil.

Fraction of Net Pay to Oil (OFRAC) — When a hydrocarbon pool is modeled as a mixed case, with both oil and gas present, the fraction of pool volume that is saturated by oil in the subsurface.

Play Chance Success — Probability that the play contains at least one pool of technically-recoverable hydrocarbons (that would flow into a conventional wellbore in a flow test or during production).

Prospect Chance Success — The fraction of prospects within the play that are predicted to contain hydrocarbon pools, given the condition that at least one pool of technically-recoverable hydrocarbons occurs within the play.

Play Type (E-F-C) — Play classification scheme.

E — **Established** play, in which significant numbers of fields have been discovered, providing the assessor with data for pool size distributions and reservoirs sufficient to allow the assessor to model the play with confidence.

F — **Frontier** play, where exploration activities are at an early stage. Some wells have already been drilled to test the play concept but no commercial fields have been established.

EXPLANATION OF DATA TABLES FOR NAVARIN BASIN ASSESSMENT PROVINCE

C	**Conceptual** play, hypothesized by analysts based on the subsurface geologic knowledge of the area. Such plays remain hypothetical and the play concept has not been tested.

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Play				Log-N Params. PORE		N (MPRO)		Reserves		Undiscovered Potentia	
				Ac/Ft	Ac/Ft	No. Pools		Gas	Oil	Gas	Oil
No.	Area	UAI Code	Name	mu	sig. sq.	Mean	Max	(BCF)	(MMB)	(BCF)	(MMB)
1	Navarin Basin	UANA0100	Miocene Transgressive Shelf Sands	11.21	2.64	11.9	44	-	-	666	78
2	Navarin Basin	UANA0200	Regressive Shelf Sands	11.41	2.52	32.2	81	-	-	2432	272
3	Navarin Basin	UANA0300	Oligocene Tectonic Sands	11.38	1.30	6.7	32	-	-	196	20
4	Navarin Basin	UANA0400	Turbidite and Submarine Fan Sands	12.19	2.01	18.1	56	-	-	2518	116
5	Navarin Basin	UANA0500	Eocene Transgressive Shelf Sands	11.95	1.81	4.6	24	-	-	336	11

PLAY		MEAN POOL SIZES OF RANKS 1 TO 3: Pool #1		Pool #2		Pool #3		INPUT DATA: Prospect Area (Acres)					
		Gas	Oil	Gas	Oil	Gas	Oil						
No.	Name	(BCF)	(MMB)	(BCF)	(MMB)	(BCF)	(MMB)	F100	F95	F75	F50	F25	F05
1	Miocene Transgressive Shelf Sands	553	24	131	41	85	24	18	381	1600	4350	11800	49700
2	Regressive Shelf Sands	1261	55	355	84	250	55	15	276	1090	2850	7410	29400
3	Oligocene Tectonic Sands	146	6	45	10	33	7	118	878	2250	4320	8310	21300
4	Turbidite and Submarine Fan Sands	1224	44	503	19	308	23	45	497	1530	3360	7370	22800
5	Eocene Transgressive Shelf Sands	285	10	105	4	66	2	45	540	1740	3910	8790	28200

PLAY		INPUT DATA: Prospect Area (Acres)			Trap Fill (Dec. Frac.)								
No.	Name	F02	F01	F00	F100	F95	F75	F50	F25	F05	F02	F01	F00
1	Miocene Transgressive Shelf Sands	91100	136400	1072600	.10	.17	.21	.24	.30	.37	.40	.41	.50
2	Regressive Shelf Sands	52400	77200	556200	.10	.18	.22	.26	.32	.40	.48	.50	.60
3	Oligocene Tectonic Sands	31600	41200	158700	.20	.32	.41	.50	.58	.71	.78	.85	1.00
4	Turbidite and Submarine Fan Sands	36600	50300	253900	.10	.21	.30	.38	.48	.63	.76	.81	1.00
5	Eocene Transgressive Shelf Sands	46100	64000	341300	.30	.44	.52	.60	.69	.80	.88	.92	1.00

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PLAY		INPUT DATA													
		Pool Area (Acres)									Pay Thickness (Feet)				
No.	Name	F100	F95	F75	F50	F25	F05	F02	F01	F00	F100	F95	F75	F50	F25
1	Miocene Transgressive Shelf Sands	3	86	396	1150	3340	15500	29500	45400	409300	16	34	50	64	83
2	Regressive Shelf Sands	3	68	295	821	2280	9950	18500	28000	231500	19	51	80	110	151
3	Oligocene Tectonic Sands	45	392	1080	2190	4440	12300	18800	25000	107600	8	19	28	40	54
4	Turbidite and Submarine Fan Sands	11	159	553	1320	3130	10900	18400	26100	156300	16	56	100	150	224
5	Eocene Transgressive Shelf Sands	26	305	1010	2410	5830	19400	34200	49300	243700	16	34	50	64	83

PLAY		INPUT DATA															
		Pay Thickness (Feet)				Oil Yield (Recov. B/Acre-Foot)								Gas Yield (MMCF/Ac.-Ft)			
No.	Name	F05	F02	F01	F00	F100	F95	F75	F50	F25	F05	F01	F00	F100	F95	F75	F50
1	Miocene Transgressive Shelf Sands	120	140	155	264	8	27	48	72	108	194	292	677	.018	.064	.116	.175
2	Regressive Shelf Sands	239	290	330	636	11	31	51	72	101	166	234	476	.036	.104	.169	.238
3	Oligocene Tectonic Sands	83	100	113	210	4	15	28	43	66	122	189	458	.014	.052	.098	.150
4	Turbidite and Submarine Fan Sands	400	510	600	1378	3	11	20	31	48	92	144	362	.008	.043	.096	.167
5	Eocene Transgressive Shelf Sands	120	140	155	264	3	9	16	22	32	54	79	167	.015	.052	.095	.143

PLAY		INPUT DATA															
		Gas Yield (MMCF/Ac.-Ft)				Solution Gas Oil Ratio (CF/B)								Gas Cond. (B/MMCF)			
No.	Name	F25	F05	F01	F00	F100	F95	F75	F50	F25	F05	F01	F00	F100	F95	F75	F50
1	Miocene Transgressive Shelf Sands	.265	.481	.730	1.713	170	260	300	320	380	430	500	550	19	30	38	41
2	Regressive Shelf Sands	.334	.545	.769	1.554	170	300	380	420	500	630	740	900	19	30	38	41
3	Oligocene Tectonic Sands	.232	.433	.671	1.642	150	290	360	410	500	630	740	900	19	30	38	41
4	Turbidite and Submarine Fan Sands	.291	.646	1.130	3.545	390	600	730	820	950	1250	1300	1400	15	26	31	38
5	Eocene Transgressive Shelf Sands	.216	.392	.594	1.393	150	360	490	600	750	1000	1200	1500	13	25	29	32

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PLAY		INPUT DATA											
PLAY		Gas Cond. (B/MMCF)				Number of Prospects in Play							
No.	Name	F25	F05	F01	F00	F99	F95	F75	F50	F25	F05	F01	F00
1	Miocene Transgressive Shelf Sands	50	60	79	80	97	102	110	115	120	126	134	135
2	Regressive Shelf Sands	50	60	79	80	167	170	175	180	185	195	199	200
3	Oligocene Tectonic Sands	50	60	79	80	122	130	140	145	150	158	161	162
4	Turbidite and Submarine Fan Sands	40	50	58	70	109	112	130	140	150	170	178	180
5	Eocene Transgressive Shelf Sands	39	48	51	60	137	140	145	150	155	160	168	170

PLAY		INPUT DATA						
		Probabilities for Oil, Gas, or Mixed Pools			Fraction of Net	Play	Prospect	
PLAY		Oil	Gas	Mixed	Pay to Oil	Chance	Chance	Play Type
No.	Name	(OPROB)	(GPROB)	(MXPROB)	(OFRAC)	Success	Success	E - F - C
1	Miocene Transgressive Shelf Sands	0	.4	.6	0.4	.56	.18	C
2	Regressive Shelf Sands	0	.4	.6	0.4	.64	.28	C
3	Oligocene Tectonic Sands	0	.4	.6	0.4	.51	.09	C
4	Turbidite and Submarine Fan Sands	0	.5	.5	0.2	.65	.20	C
5	Eocene Transgressive Shelf Sands	0	.75	.25	0.1	.56	.05	C

EXPLANATION OF NAVARIN BASIN PLAY SUMMARIES

This section consists of page-size compilations of graphics that summarize the results of ***GRASP*** modeling of the undiscovered, conventionally recoverable oil and gas endowments of each of the plays identified and assessed in the province. Each play summary features a plot for risked cumulative probability distributions for oil, gas, and BOE (gas in oil-equivalent barrels added to oil), a table of results, and a plot showing ranked sizes (oil and gas shown separately) of individual hypothetical pools. These three components of the play summaries are each described below.

Risked Cumulative Probability Distributions for Plays

Each play summary provides, at page top, cumulative probability distributions for risked, undiscovered endowments of conventionally recoverable oil, gas, and BOE. Oil and BOE quantities are shown in billions of barrels (B bbl). Gas quantities are reported in trillions of cubic feet (Tcf). Resource quantities are plotted against "Cumulative frequency greater than %." A cumulative frequency value represents the probability that the play resource endowment will exceed the quantity associated with the frequency value along one of the curves (fig. 0.1). Cumulative frequency values along the curves decrease as resource quantities increase. Accordingly, the cumulative frequencies, or "probabilities for exceedance," of small resource quantities are high, and conversely, the probabilities for exceedance of large resource quantities are low.

The cumulative probability distributions are risked and curves are truncated approximately at the output play chance. In most plays, the output play chance is equal to the input play chance for success. However, in plays with very small numbers of pools, the output play chance may be significantly **lower** than the input play chance for success.

The output play chance is derived from MPRO, a module within ***GRASP*** which uses inputs for geologic chance of success to convert probability distributions for numbers of ***prospects*** to probability distributions for numbers of ***pools***. The output play chance is obtained as a mathematic extrapolation to the probability at which the numbers of pools meets or exceeds zero. In plays with 5 or more pools at the mean, this probability usually equals the input play chance for success. In plays with less than 5 pools at the mean, the zero-pool probability (or output play chance) may be much less than the input play chance. Deviation between the output play chance and the input play chance is greatest in those plays with mean numbers of pools less than unity. Such highly risky plays contribute very little resources to overall province endowments.

Identification numbers beginning with "UA" in the graphics labels are codes unique to each of the plays in the ***GRASP*** data bases.

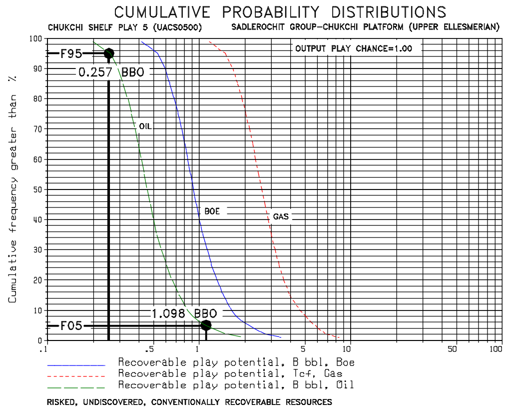
Table for Risked Play Resource Endowments

Each play summary provides, at page center, a table for risked, undiscovered play endowments of oil, gas, and BOE in billions of barrels of oil (BBO) or trillions of cubic feet of gas (TCFG). Quantities are reported at the **mean**, **F95** (a low estimate having a 95-percent frequency of exceedance), and **F05** (a high estimate having a 5-percent frequency of exceedance). Tabulated resource quantities are risked and therefore correspond to points on the cumulative probability distributions shown at page top. For plays with chances for success (play level) less than 0.95, the risked resource quantities reported at **F95** are zero.

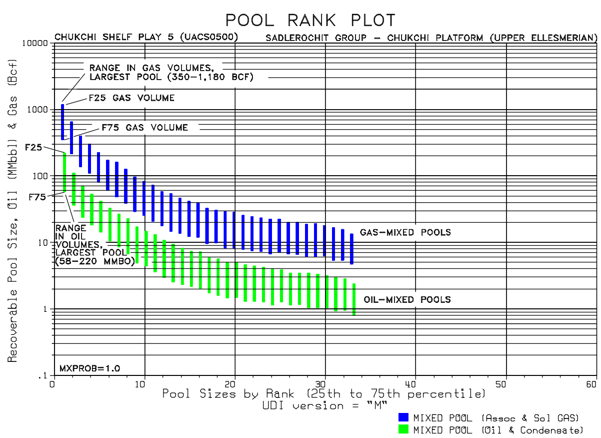
Ranked Pool Size Distributions for Plays

Each play summary provides, at page bottom, a plot showing pool sizes ranked according to size in BOE. The numbers of pools shown in the rank plots correspond to the maximum numbers of pools estimated to occur within the plays. Each pool in a pool rank plot is represented by a pair of adjoining vertical bars. The left bar of each pair represents the range (from **F75** to **F25** in the output probability distribution) of gas recoverable from the pool, and may include non-associated gas from an all-gas pool or associated gas from a gas cap and/or solution gas from oil, depending on pool type. The right bar of each pair represents the range (from **F75** to **F25**) of petroleum liquids recoverable from the same pool, and may include free oil, condensate from a gas cap, or condensate from a gas-only pool.

Volumes are shown in millions of barrels (MMbbl) of oil and billions of cubic feet (Bcf) of gas.



CHUKCHI SHELF PLAY 5 (UACS0500)			
FRACTILES	F95	MEAN	F05
GAS (TCFG)	1.478	2.993	5.823
OIL (BBO)	0.257	0.537	1.098
BOE (BBO)	0.530	1.069	2.125



The upper graph and the table report the volumes of risked, undiscovered, conventionally recoverable resources for the play. The graph, called a ***cumulative probability distribution***, shows three curves (oil, BOE, and gas) and reports the output play chance at upper right. The output play chance for Chukchi shelf play 5 is 1.0, meaning that there is a 100-percent chance that at least one hydrocarbon pool exists somewhere within the play. To illustrate how to read the graphs, dots have been placed on the ***oil*** curve at cumulative frequency values (vertical axis) of 95-percent and 5-percent. The corresponding oil quantities are 0.257 and 1.098 billions of barrels of oil. Thus, for Chukchi shelf play 5, there is a 95-percent chance that at least 0.257 billion barrels of oil are present and a 5-percent chance that more than 1.098 billion barrels are present. These same oil quantities are listed at F95 and F05 in the table.

The lower graph provides information about pool volumes and is called a ***pool rank plot***. This graph shows two sets of vertical bars, representing the quantities of oil and gas occurring ***together*** in 33 pools, the maximum number estimated to occur within this play. All pools in play 5 are modeled as mixed, that is, containing oil with a gas cap; other plays may also have all-gas or all-oil pools and show six separate commodities. Each pair of gas-oil bars in the play 5 pool rank plot shows the volume of oil in the pool and the volume of gas in the cap. The vertical bars extend across a range of possible volumes for each pool. The lower end of each bar represents the F75 resource quantity, meaning that the pool, if it exists, has a 75-percent chance of exceeding the corresponding resource quantity. Likewise, the upper end of each bar represents the F25 resource quantity. In Chukchi play 5, the largest pool offers oil volumes in the range from about 58 (F75) to 220 (F25) million barrels and gas volumes in the range from 350 (F75) to 1,180 (F25) billion cubic feet.

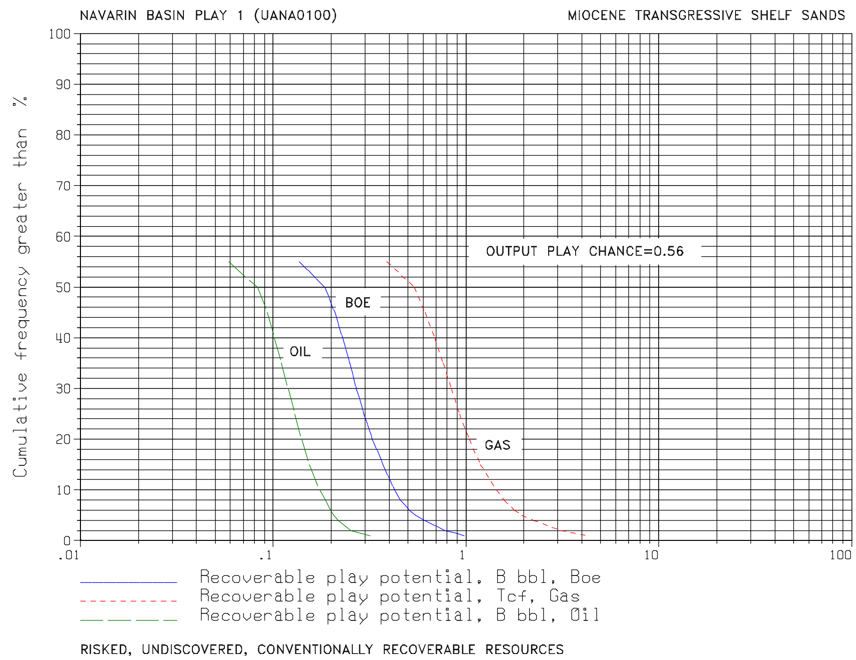
Figure 0.1: Sample play summary, Chukchi shelf play 5.

Extreme sizes outside the range between F75 and F25 volumes are not shown, but all pools offer (at low probabilities) high-side potential that may be several multiples of their median sizes (F50 or centers of vertical bars). For example, the largest pool in the pool rank plot in figure 0.1 shows F75-F25 ranges in oil volumes from 58 to 220 millions of barrels and gas volumes from 350 to 1,180 billions of cubic feet. But, these ranges do not capture the largest possible sizes of pool rank 1. This same pool has a 5-percent chance of containing over 600 million barrels of oil and 3,070 billion cubic feet of gas, or a 1-percent chance of containing over 1,140 million barrels of oil and 6,180 billion cubic feet of gas!

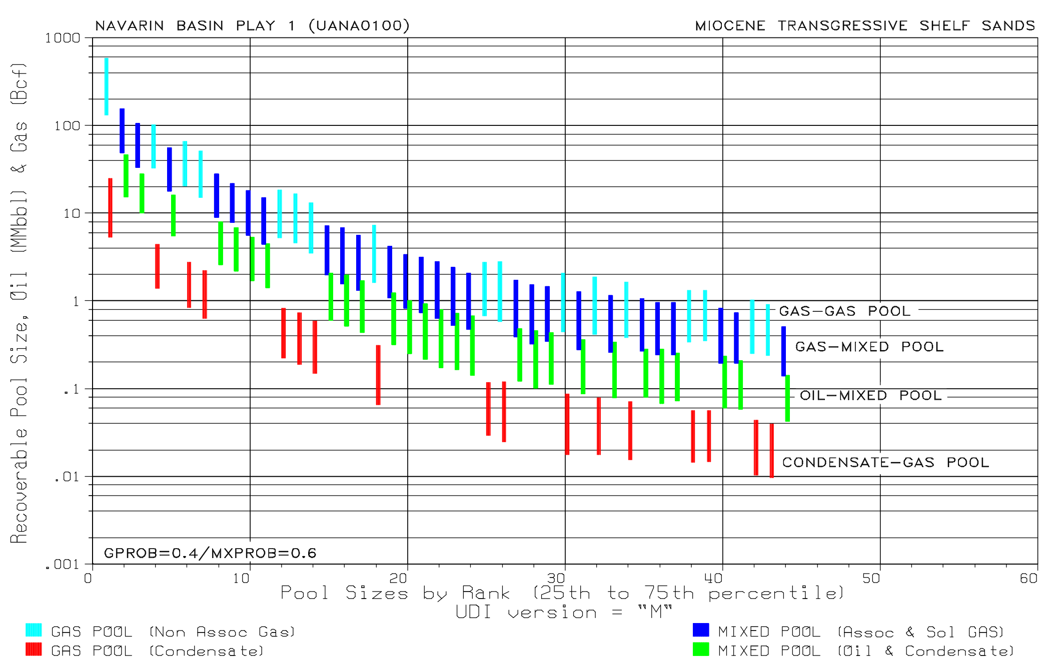
Although it might be interesting to portray the improbable yet extreme-high potential sizes of pools, choosing fractiles ranging up to F01 results in an uninformative plot where all pools nearly reach the top of the plot. For this presentation, a range based on F75-F25 values was chosen for visual clarity while still giving some impression of variance or spread.

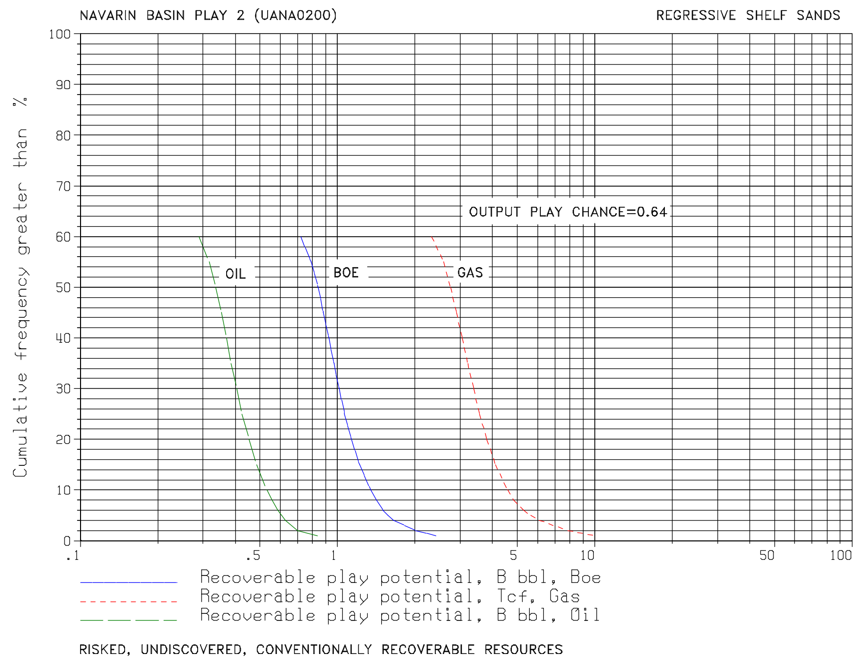
Pool volumes shown in the ranked plots are conditional upon success at the play level (i.e., a hydrocarbon pool existing ***somewhere*** within the play). The sizes of the pools posted in the rank plot have not been "risked", or multiplied against play chance of success. Therefore, except where the play chance of success equals 1.0, the sum of the mean sizes of the pools in the rank plot will exceed the risked mean play endowment that is reported in the table at page center. In fact, several of the largest pools, or even just the largest pool, may post conditional resources exceeding the risked play endowment.

Designation of pool types (oil-only, versus oil with gas cap, versus gas-only) within the play model was controlled by three data entries. Each play was assigned probabilities for (or frequencies of) occurrence of any of three pool types within the play—"OPROB" for oil-only pools, "GPROB" for gas-only pools, and "MXPROB" for mixed (oil and gas cap) pools. As the model recognizes only these three pool types, these three probability values always sum to 1.0. The three probability values control frequency of pool type sampling during ***GRASP*** runs, and, with a random number generator in ***GRASP***, ultimately dictate the sequence of pool types that appear in the play pool rank plots. The OPROB, GPROB, and/or MXPROB values that were used in the play models are posted, as appropriate, in the lower left corner of each pool rank plot.

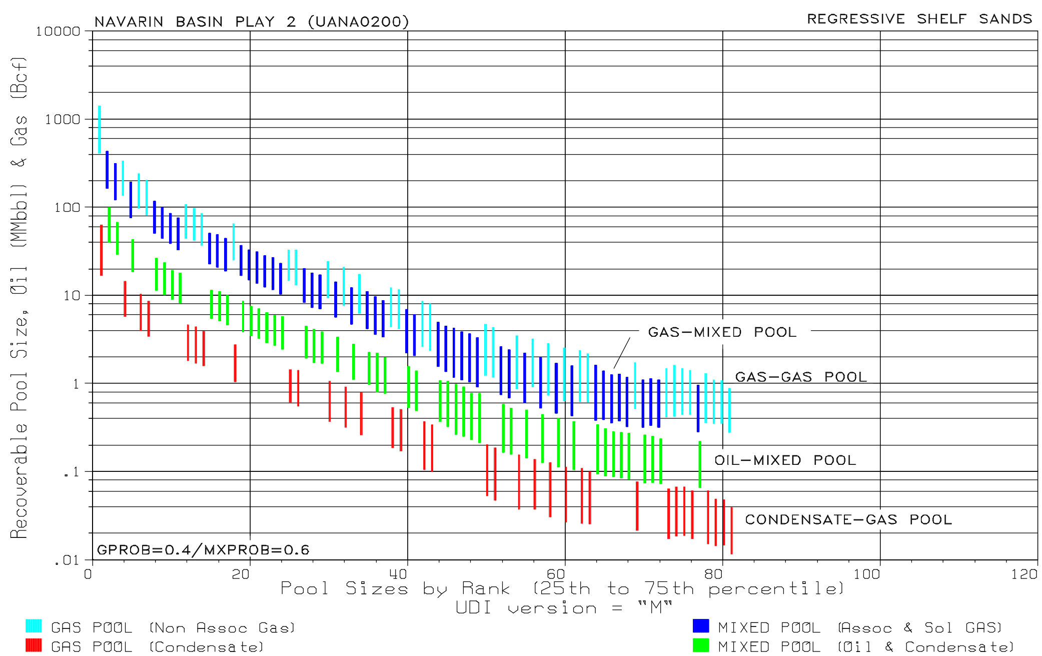


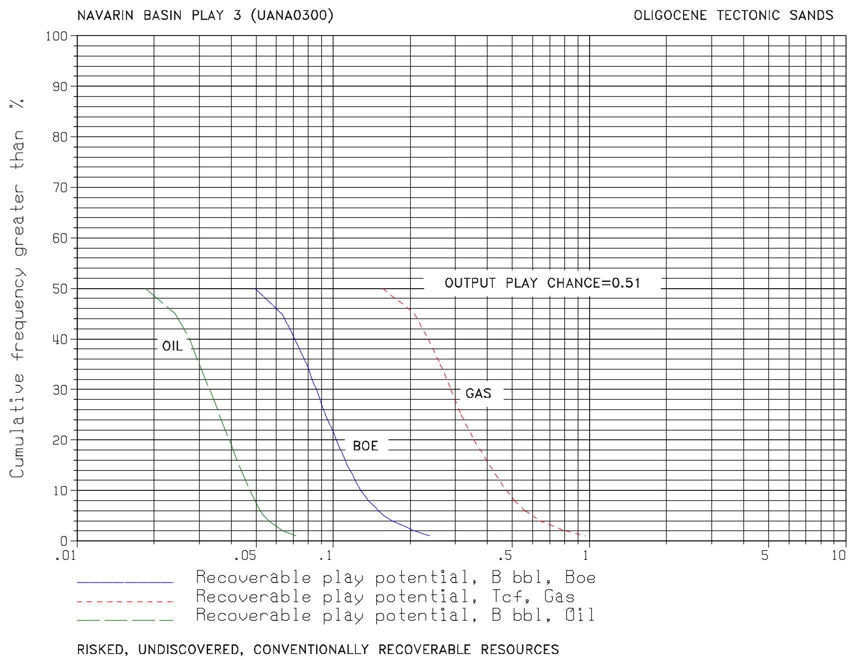
NAVARIN BASIN PLAY 1 (UANA0100)			
FRACTILES	**F95**	**MEAN**	**F05**
GAS (TCFG)	**0.000**	**0.666**	**1.951**
OIL (BBO)	**0.000**	**0.078**	**0.206**
BOE (BBO)	**0.000**	**0.196**	**0.550**



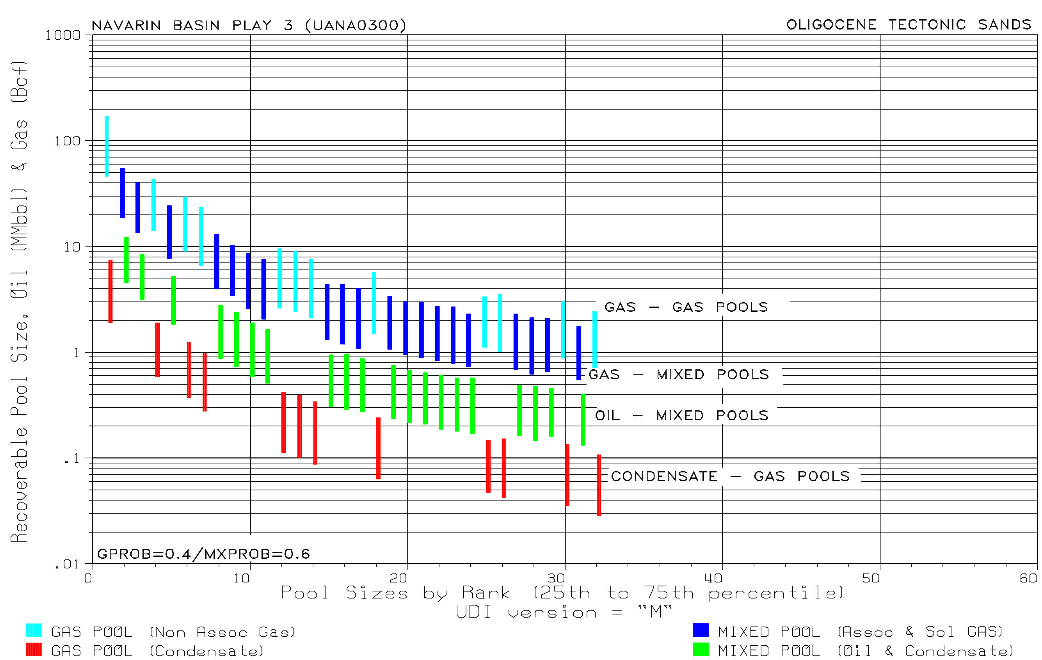


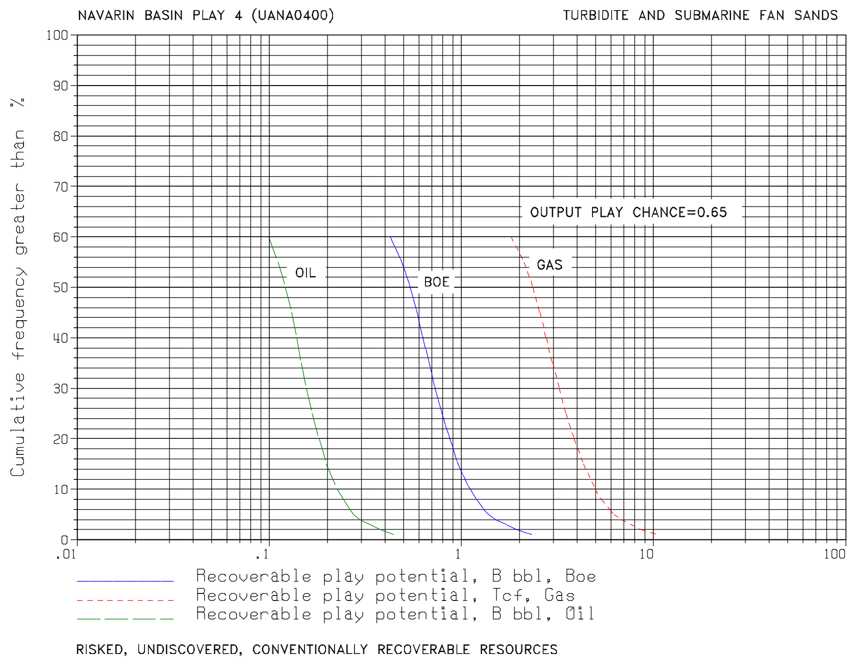
NAVARIN BASIN PLAY 2 (UANA0200)			
FRACTILES	**F95**	**MEAN**	**F05**
GAS (TCFG)	**0.000**	**2.432**	**5.655**
OIL (BBO)	**0.000**	**0.272**	**0.605**
BOE (BBO)	**0.000**	**0.705**	**1.566**



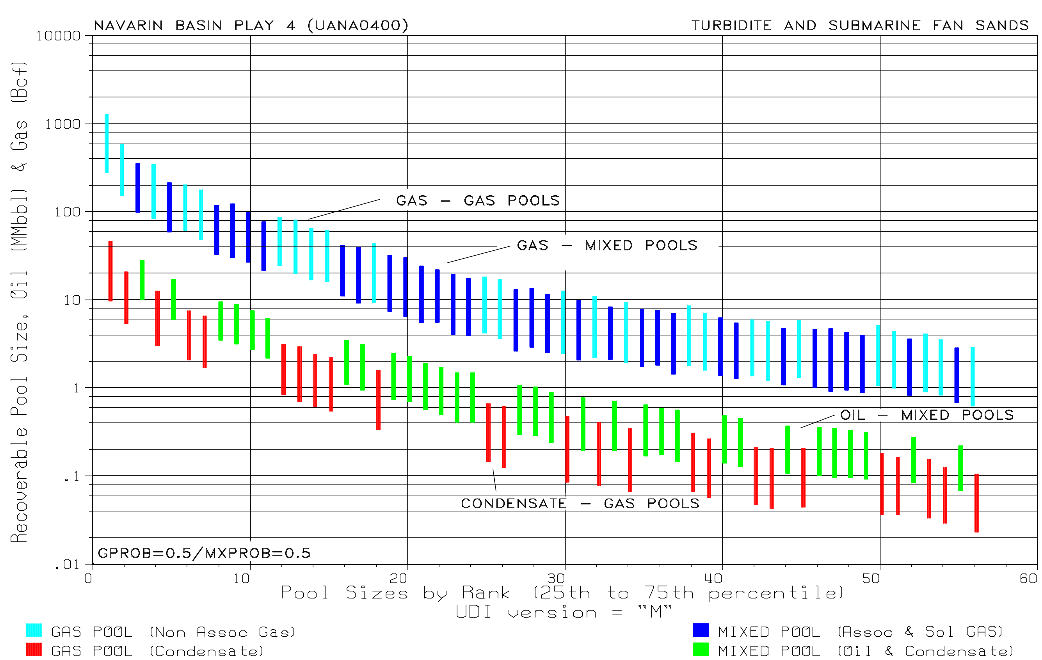


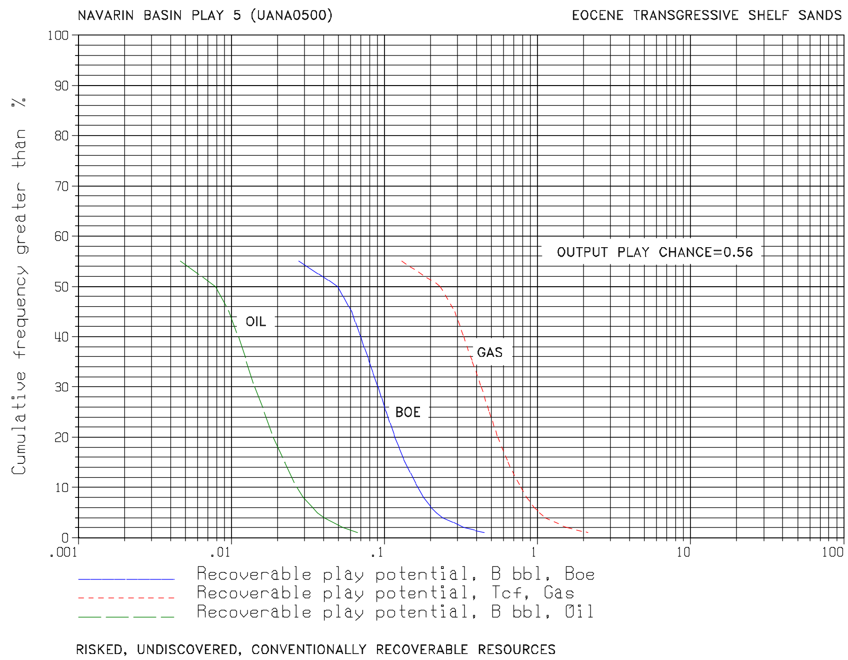
NAVARIN BASIN PLAY 3 (UANA0300)			
FRACTILES	**F95**	**MEAN**	**F05**
GAS (TCFG)	**0.000**	**0.196**	**0.599**
OIL (BBO)	**0.000**	**0.020**	**0.054**
BOE (BBO)	**0.000**	**0.054**	**0.158**



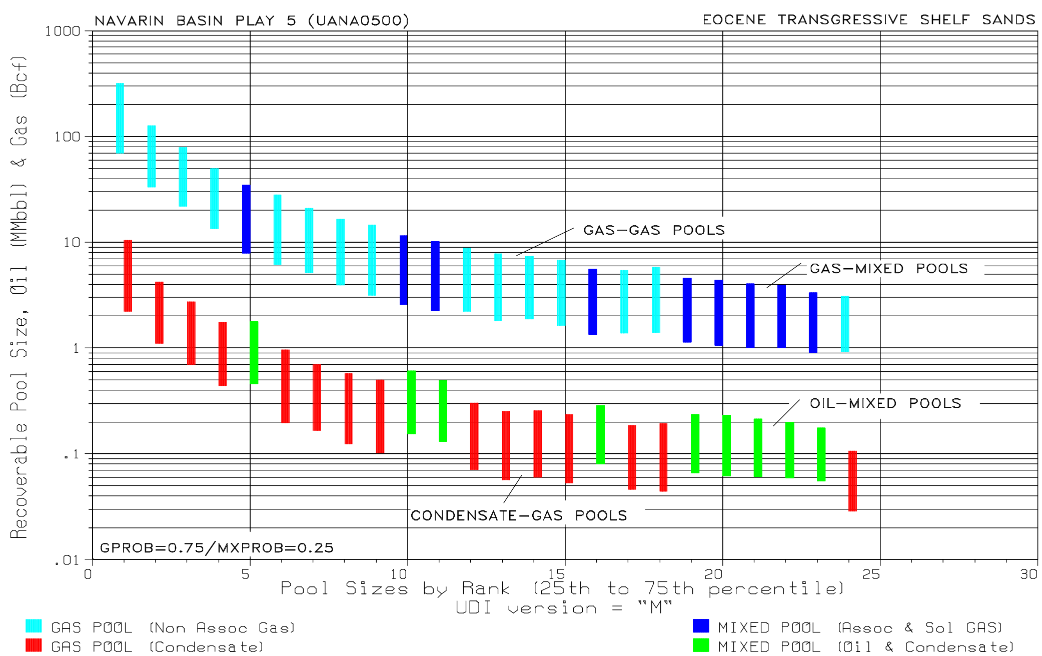


NAVARIN BASIN PLAY 4 (UANA0400)			
FRACTILES	**F95**	**MEAN**	**F05**
GAS (TCFG)	**0.000**	**2.518**	**6.236**
OIL (BBO)	**0.000**	**0.116**	**0.275**
BOE (BBO)	**0.000**	**0.564**	**1.388**





NAVARIN BASIN PLAY 5 (UANA0500)			
FRACTILES	**F95**	**MEAN**	**F05**
GAS (TCFG)	**0.000**	**0.335**	**1.024**
OIL (BBO)	**0.000**	**0.011**	**0.036**
BOE (BBO)	**0.000**	**0.071**	**0.218**



ECONOMIC RESULTS, NAVARIN BASIN PROVINCE

(James D. Craig)

INTRODUCTION

This section summarizes the results of economic modeling using the *PRESTO-5* (*P*robabilistic *R*esource *EST*imates-*O*ffshore, version 5) computer program. The economic assessment results are influenced, to a large degree, by the undiscovered, conventionally recoverable oil and gas resources assessed using the *GRASP (G*eologic *R*esource *AS*sessment *P*rogram) computer model. The conventionally recoverable results are discussed in separate .pdf files (*Summaries of Play Results, with Cumulative Probability and Ranked Pool Plots*).

Each province summary page includes three illustrations: (1) cumulative probability plots for risked, conventionally recoverable resource distributions (oil, gas, and BOE); (2) a table comparing risked, mean, conventionally recoverable resources with the risked, mean, economically recoverable resources at current commodity prices; and (3) a price-supply graph displaying economically recoverable resource curves.

The province summary page is followed by a table reporting play-specific, economically recoverable resource estimates for two representative price scenarios: a Base Price scenario ($18/bbl-oil, $2.11/MCF-gas) representing current market conditions; and a High Price scenario ($30/bbl-oil, $3.52/MCF-gas).

PROVINCE SUMMARY PAGE

Risked Cumulative Probability Distributions

The province summary page provides, at page top, cumulative probability distributions for risked, undiscovered endowments of conventionally recoverable oil, gas, and BOE, where resource quantities are plotted against "cumulative frequency greater than %." A cumulative frequency represents the probability that the resource endowment is equal or greater than the volume associated with that frequency value along one of the curves. For example, a 95% probability represents a 19 in 20 chance that the resource will equal, or be higher than, the volume indicated. Cumulative frequency values typically decrease as resource quantities increase. An expanded description of cumulative probability plots is given in "*Summaries of Play Results, with Cumulative Probabilities and Ranked Pool Plots* " provided as a separate .pdf file.

Table of Risked Play Resources

The province summary page provides, at page center, a table comparing the total conventionally recoverable endowment and the smaller quantity of economically recoverable resources that could be profitably extracted under current economic and engineering conditions. Current prices are represented as $18 per barrel of oil and $2.11 per MCF of gas, where gas price is linked to oil price by energy equivalency and discount-value factors (5.62 MCF per barrel; 0.66 value discount). Conventional resource volumes correspond to points on the cumulative probability distributions (at page top). Economic resource volumes correspond to points along the mean price-supply curve (at page bottom). Resources listed as negligible (negl) have volumes lower than the significant figures shown. Not Available (N/A) means that these resources are unlikely to be produced in the foreseeable future because of reservoir conditions or the lack of a viable transportation infrastructure.

The ratio of economic to conventional resources indicates the proportion of the total undiscovered endowment that is profitable to produce under current commodity prices with proven engineering technology. However, for production to occur, commercial discoveries must be made, and the analysis does not imply discovery rates. Given the size and geologic complexity of the offshore provinces, exploration will require extensive drilling, and considering the relatively low chance of commercial success and the high cost of exploration wells, many of these frontier provinces are not likely to be thoroughly tested in the foreseeable future. The ratio of economic to conventional resources should be regarded as an opportunity indicator, rather than as a direct scaling factor for readily available hydrocarbon reserves.

Price-Supply Curves

The province summary page includes, at page bottom, a graph showing price-supply curves representing Low, Mean , and High resource production scenarios. Price-supply curves illustrate how volumes of economically recoverable resources increase as a function of commodity price. Characteristically, increases in commodity price result in corresponding increases in economically recoverable resource volumes. The economic resource volumes represent oil and gas, as yet undiscovered, that could be recovered profitably given the modeled economic and engineering parameters. At very high prices, the mean curve approaches the mean total resource endowment estimated by *GRASP*. The price-supply curves do not imply that these resources will be discovered or produced within a specific time frame, only that the opportunity exists for commercial production at levels controlled by commodity prices.

The price-supply curves were generated by the *PRESTO-5* computer program, which simulates the exploration, development, production, and transportation of pooled hydrocarbons in geologic plays within a petroleum province. Economic viability depends on the interaction of many factors defining the size and location of the hydrocarbon pools, the reservoir engineering characteristics, and economic variables relating expenditures to income from future production streams. The economic simulation is quite complex, owing to the complexities in the state of nature, and requires a sophisticated analytical model.

The following is a brief overview of the *PRESTO-5* modeling process. Geologic parameters (for example, reservoir thickness, pool area, risk) used by the *GRASP* computer model to determine conventionally recoverable resources are transferred into the *PRESTO-5* model through an interface program. Economic viability is determined by performing a discounted cash flow analysis on the expenses and modeled production stream for each pool simulated in a given trial. A Monte Carlo (random sampling) process selects engineering parameters (for example, production rate profiles, well spacing, platform installation scheduling), and cost variables (for example, platforms, wells, pipelines) from ranged distributions. Each simulation trial models the expenses, scheduling, and production for pools "discovered" within a particular play. The sampling process is repeated for productive pools in all geologic plays, and the economic resources are aggregated to the province level. The development simulation process is repeated, typically for 1000 trials, at given set of prices (oil and gas prices are linked). After the specified number of trials are completed for the first set of oil and gas prices, a new set of prices is selected and another round of simulation trials is run. This process continues for approximately 30 iterations, yielding a range of economic resource volumes tied to commodity prices. The results for all runs are given as probability distributions, where selected probability levels can be displayed as continuous price-supply curves.

These analyses determine the resource volumes that are commercially viable under a specific set of current economic and engineering assumptions. No attempt was made to upgrade engineering technology or development strategies that might be implemented in response to higher commodity prices.

The price-supply curves provided in this report are based on the most likely development scenario tailored for each particular province. All provinces were modeled on a stand-alone basis, with engineering assumptions designed for the primary hydrocarbon substance (oil or gas) identified by the *GRASP* analysis. Generally, the secondary hydrocarbon is less economically viable and places an extra burden on the primary hydrocarbon substance. For provinces without existing oil and gas infrastructure, the modeling scenarios were designed assuming that the primary substance would drive initial development in a particular province. Oil-prone provinces were modeled as "oil-only" production, with gas reinjected for reservoir pressure maintenance to maximize oil recovery. Gas-prone provinces were modeled with both gas and oil production because natural gas-liquids (or condensates) are not reinjected. Often the volume of condensates in gas-prone provinces exceeds any volume of non-associated crude oil. All hydrocarbon liquids are commingled in production and transportation systems.

This economic analysis assumes 1995 as the base year. Higher nominal commodity prices in the future (price increases only at the rate of inflation) do not result in higher estimated volumes of economically recoverable resources, whereas higher real commodity prices (increases above the rate of inflation) do increase the economically recoverable resources. The economic model assumes that commodity price and infrastructure costs were inflated equally at an assumed 3% annual inflation rate (flat real price and cost paths). The price-supply curves can be used to project economic resource volumes relative to future price if appropriate discounting back to the 1995 base year is made to account for real price and real costs changes in the intervening years.

The price-supply graph usually contains three curves, corresponding to Low, Mean, and High resource production levels. The Low resource case represents a 95% probability (19 in 20 chance) that the resources are equal to, or exceed, the volumes derived from the price-supply curves. The High resource case represents the 5% exceedance level (1 in 20 chance). The Mean resource case represents the average. In high-cost and high-risk provinces, where there are no economically recoverable resources at the 95% probability level, no "Low" curve is displayed. An apparent anomaly is observed in some cases where the lower tail of the "Mean" price-supply curve indicates economic resources greater than the "High" (5% probability) curve. This situation occurs at low prices where the probability of economic success drops below 5%, and the Mean curve is obtained from the few productive trials occurring at probabilities below 5%.

A few additional observations concerning price-supply curves are noteworthy. Following established convention for price-supply curves, these graphs are rotated from the usual mathematical display of X-Y plots. Although shown along the vertical (Y) axis, price is the independent variable and resource is the dependent variable. In many of the gas-prone basins, price-supply curves will display an abrupt step below which no risked economically recoverable resources are modeled. This step corresponds to the minimum resource value required to overcome the cost of production and transportation infrastructure. Because of the distances to Asian markets, the assumed destination for Alaska gas production, natural gas must be converted to liquid form for transportation by ships. The infrastructure associated with conversion into liquefied natural gas (or LNG) does not lend itself to incremental additions for grassroots projects; therefore, an abrupt "cost-hurdle" created by large LNG and marine terminal installations must be overcome by significant resource volumes.

Finally, the reader must be aware that these price-supply curves are models of risked hydrocarbon resources. Both the geologic risk that the resources are pooled and recoverable as well as the economic risk that development is profitable under the assumed economic and technologic conditions are factored into the reported results. This means that although very low resource volumes are reported as "economically recoverable", these low volumes, in fact, do not correspond to actual quantities of oil or gas. At low prices, risk is dominated by economic factors associated with engineering cost and reservoir performance variables. At high prices, risk is dominated by geologic factors related to volumetric variables. **Risked price-supply curves are most appropriately used to define the comparative potential of petroleum provinces under changing price and probability conditions.** They do not predict the timing of resource discovery or rate of conversion of undiscovered resources to future production. As previously stated, future production of the modeled economically recoverable resources will require extensive exploration programs. In the Alaska offshore, future leasing and exploration activities are likely to be driven by "high-side potential", combining perceptions of greater rewards at higher risk, higher future commodity prices, and innovative technology to reduce costs.

TABLE FOR PLAY RESOURCE DISTRIBUTIONS

The risked mean contribution for each geologic play in the province is tabulated under two hypothetical price conditions. The Base Price ($18 per barrel-oil; $2.11 per MCF-gas) represents current economic conditions. The High Price ($30 per barrel-oil; $3.52 per MCF-gas) represents a situation where real price has increased significantly from current levels. Other economic parameters (for example, discount rate and corporate tax rate) were equal in both scenarios, as were engineering technology and cost assumptions. The play number, name, and *UAI* (*U*nique *A*ssessment *I*dentifier code) provide a link to the data presented in other sections of this report. Hydrocarbon substances are distinguished as oil (includes crude oil and gas-condensate liquids), gas (includes non-associated, associated, and dissolved gas), and BOE (gas volume is converted to barrel of oil equivalent and added to oil volume).

NAVARIN BASIN MODELING RESULTS

The Navarin basin province was modeled for the simultaneous production of gas and oil resources. Natural gas, as the dominant hydrocarbon, is assumed to support the development activities in the province, with crude oil and natural gas liquids (condensates) recovered by utilizing gas production infrastructure (platforms). As there is no petroleum infrastructure in the northern Bering Sea, new transportation facilities are required in the province as well as on the Alaska Peninsula.

The development scenario assumes that gas produced from floating offshore platforms would be transported by a 700 mile subsea pipeline to a new facility in Balboa Bay on the south side of the Alaska Peninsula where it will be converted to liquefied natural gas (LNG). LNG would be shipped by marine carriers to markets in Japan. Using a great-circle tanker route, this terminal is 3000 miles from the assumed landing port in Japan (Yokohama). Natural gas liquids and crude oil would be transported by pipeline to a offshore storage and loading terminal at a central location between producing fields. Ice-reinforced tankers would shuttle commingled oil and condensate to a transshipment terminal at Balboa Bay, continuing then by conventional tankers to West Coast markets (Los Angeles).

Under the Base Price condition ($2.11 per MCFG), the Navarin basin province contains an estimated 0.04 TCFG of risked mean economically recoverable gas and a negligible volume of economically recoverable oil. At the High Price condition ($3.52 per MCFG), this province contains 0.075 TCFG of economically recoverable gas, still only 1.2% of the mean gas endowment. The poor economic viability can be attributed to small hydrocarbon pool size, poor reservoir properties, and very high development and transportation costs. The development cost hurdle is overcome at a gas price of above approximately $7.00 per MCFG, above which significant volumes of gas resources are recoverable for both the Mean and High resource cases. For example, at $8.00 per MCFG (over twice the current overseas LNG price), the economically recoverable gas resource in the Mean resource case is 1.8 TCFG. For the High resource case (1 in 20 chance), 7.6 TCFG are economic to produce from the Navarin basin. To achieve such an optimistic price and production scenario would require both a substantial increase in real gas prices as well as an aggressive exploration program to discover the resources. It is very unlikely that oil development in the Navarin basin would be economically viable, at reasonable commodity prices, without the benefit of associated gas production infrastructure.

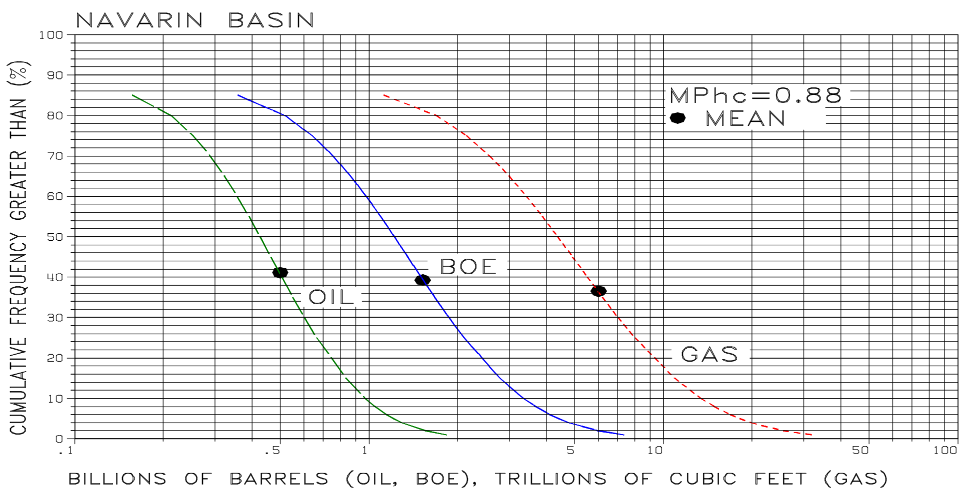
Gas resources in the Navarin basin occur in 5 geologic plays, with one play (Turbidite and Submarine Fan, Play 4) containing most of the economically recoverable gas resources under both price conditions (94% at Base Price and 76% at High Price), with estimated (mean) gas pool sizes ranging up to 1.2 TCFG. Although this province has been tested by 8 exploration wells and 1 stratigraphic test well, no wells have tested the basinal turbidite prospects grouped into Play 4. Given that no wells have tested this play, it is considered to be speculative.

Gas production from the Navarin basin province is very unlikely on a stand-alone basis because of relatively small pool sizes and high development and transportation costs. However, co-development strategies with adjacent provinces might improve the economic opportunity in this province. For example, the long subsea pipeline cost could be partially supported by gas production from St. George basin, and utilizing an existing LNG plant and marine terminal on the Alaska Peninsula would eliminate a multi-billion dollar capital cost. Future exploration interest is likely to be driven by the high-side potential (which accepts higher rewards at higher risks), presumably focused on the untested turbidite reservoirs of Play 4.

Economic Results for Navarin basin assessment province. (A) Cumulative frequency distributions for **risked, undiscovered conventionally recoverable resources** ; (B) Table comparing results for conventionally and economically recoverable oil and gas; (C) Price-supply curves for **risked, economic gas** at mean and high (F05) resource cases.

BOE, total oil and gas in energy-equivalent barrels; MPhc, marginal probability for occurrence of pooled hydrocarbons in basin; BBO, billions of barrels; TCFG, trillions of cubic feet.

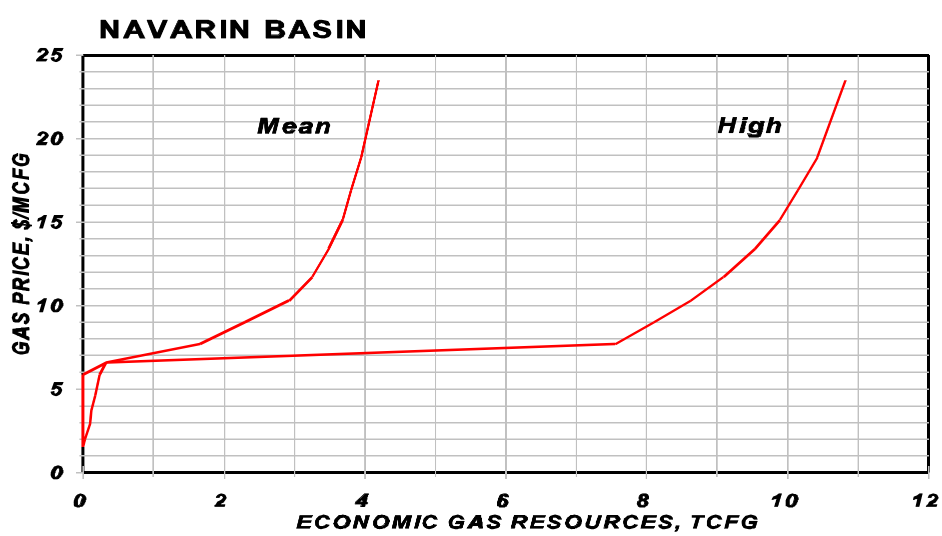
A.



B.

NAVARIN BASIN PROVINCE		
RESOURCE TYPE	MEAN OIL (BBO)	MEAN GAS (TCFG)
CONVENTIONALLY RECOVERABLE	0.50	6.15
ECONOMICALLY RECOVERABLE ($18)	negl	0.04
RATIO ECONOMIC/CONVENTIONAL	negl	negl

C.



OIL AND GAS RESOURCES OF NAVARIN BASIN PLAYS

Risked, Undiscovered, Economically Recoverable Oil and Gas

PLAY NO.	PLAY NAME (UAI * CODE)	BASE PRICE			HIGH PRICE		
		OIL	GAS	BOE	OIL	GAS	BOE
1.	Miocene Transgressive Shelf Sands (UANA0100)	negl	0.002	negl	negl	0.004	0.001
2.	Regressive Shelf Sands (UANA0200)	0.000	0.000	0.000	0.001	0.014	0.003
3.	Oligocene Tectonic Sands (UANA0300)	0.000	0.000	0.000	0.000	0.000	0.000
4.	Turbidite and Submarine Fan Sands (UANA0400)	0.001	0.034	0.007	0.002	0.057	0.012
5.	Eocene Transgressive Shelf Sands (UANA0500)	0.000	0.000	0.000	0.000	0.000	0.000
	TOTAL	***0.001***	***0.036***	***0.007***	***0.003***	***0.075***	***0.016***

* *Unique Assessment Identifier, code unique to play.*

OIL is in billions of barrels (BBO). **GAS** is in trillion cubic feet (TCF).
BOE is barrel of oil equivalent barrels, where 5,260 cubic feet of gas = 1 equivalent barrel-oil

For direct comparisons among provinces, two prices are selected from a continuum of possible price/resource relationships illustrated on price-supply curves. **BASE PRICE** is defined as $18.00 per barrel for oil and $2.11 per thousand cubic feet for gas. **HIGH PRICE** is defined as $30.00 per barrel for oil and $3.52 per thousand cubic feet for gas. Both economic scenarios assume a 1995 base year, flat real prices and development costs, 3% inflation, 12% discount rate, 35% Federal corporate tax, and 0.66 gas price discount.

Shaded columns indicate the most likely substances to be developed in this province. Economic viability is indicated on price-supply curves which aggregate the play resources in each province.