

Cook Inlet Play 4: Tertiary Gas Play

Geological Assessment

GRASP UAI: AAAAAACAE

Play Area: 825 square miles

Play Water Depth Range: 50-200 feet

Play Depth Range: 3,000-6,000 feet

Play Exploration Chance: 0.225

| Play 4, Tertiary-Gas, Cook Inlet (Federal) 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 | 136 | 400 |
| Total Gas (Tcfg) | 0.000 | 0.767 | 2.247 |
| Total Liquids (bbl) | 0 | 7 | 20,389 |
| Free Gas** (Tcfg) | 0.000 | 0.767 | 2.247 |
| Solution Gas (Tcfg) | 0.000 | 0.000 | 0.000 |
| Oil (bbbl) | 0 | 0 | 0 |
| Condensate (bbl) | 0 | 7 | 20,389 |
| * 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 4, the “Tertiary Gas” play, is the least important play (of four plays) in the Cook Inlet OCS Planning Area, with 11% (136 Mmboe) of the Planning Area hydrocarbon energy endowment. The overall assessment results for play 4 are shown in [table 1](#). Dry gas forms 100% of the energy endowment of play 4. [Table 5](#) reports the detailed

assessment results by commodity for play 4.

[Table 3](#) summarizes the volumetric input data developed for the *GRASP* computer model of Cook Inlet play 4. [Table 4](#) reports the risk model used for play 4. The location of play 4 is shown in [figure 1](#).

This play is restricted to the northernmost part of the Planning Area, north of the Augustine-Seldovia arch. It is a continuation of the Upper Tertiary gas play of upper Cook Inlet. The source of the gas is biogenic methane in coal beds and carbonaceous siltstones (Claypool and others, 1980). Non-associated dry gas was first discovered in the basin onshore in the Kenai field in 1959 (Brimberry and others, 2002). That field is the largest discovery to date, with ultimate recovery estimated at 2.4 Tcfg. Dry gas fields in upper Cook Inlet and adjacent onshore areas produced more than 6.1 Tcfg through 2003 with remaining reserves estimated at 1.8 Tcfg. The ultimate recovery of non-associated dry gas from known fields is estimated to be more than 7.9 Tcfg (Thomas and others, 2004).

Play 4 includes non-marine sandstone reservoirs in the upper Tyonek Formation and the Beluga Formation of Miocene age. The overlying Sterling Formation, which is productive in upper Cook Inlet, is too shallow in Federal waters to be viable. According to Van Kooten (2003), about 92 percent of the discovered gas in the basin is found at depths between 3,000 and 5,100 feet. That depth range corresponds to the optimum temperature for metabolic activity for methane generation given the heat flow of the basin. In most of the OCS Planning Area, Upper Tertiary strata are shallower

than 3,000 feet, so play 4 is restricted to a relatively small area. Gas recovery for play 4 is modeled on performance from upper Cook Inlet fields for Beluga and Tyonek sands, which are 600 to 1,150 mcf per acre-foot and 490 to 1,150 mcf per acre-foot respectively (Clifford, 2004).

Potential traps in play 4 are identical to play 1. These include anticlines cored by reverse faults and stratigraphic traps in fluvial channels and alluvial fans. The source-rock and reservoir-rock viability are well established in play 4. However, the limited areal extent of Upper Tertiary strata at optimum depths for methane generation is a major constraint on resource potential in Federal waters. Play 4 contains both the largest technically and economically recoverable gas resources in the Cook Inlet Planning Area, but the other three plays have more potential resources when compared on a BOE basis. On the other hand, proximity to infrastructure and future demand for natural gas in south-central Alaska are positive considerations for the Tertiary gas play.

A maximum of 18 hypothetical pools is forecast by the aggregation of the risk model and the prospect numbers model for play 4. These 18 pools range in mean conditional (un-risked) recoverable volumes from 5 Mmboe (pool rank 18) to 87 Mmboe (pool rank 1), or from 0.028 Tcfg to 0.489 Tcfg when expressed as gas. Pool rank 1 ranges in possible conditional recoverable volumes from 19 Mmboe (F95) to 214 Mmboe (F05), or from 0.107 Tcfg (F95) to 1.202 Tcfg (F05) when expressed as gas. [Table 2](#) shows the conditional sizes of the 10 largest pools in play 4.

| Play 4, Tertiary-Gas, Cook Inlet (Federal) 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 | 19 | 87 | 214 |
| 2 | 10 | 45 | 105 |
| 3 | 7 | 30 | 66 |
| 4 | 5.3 | 22 | 49 |
| 5 | 4.4 | 18 | 39 |
| 6 | 3.9 | 15 | 33 |
| 7 | 3.5 | 13 | 28 |
| 8 | 3.2 | 12 | 25 |
| 9 | 3.0 | 11 | 22 |
| 10 | 2.8 | 10 | 20 |
| * 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

In the computer simulation for play 4 a total of 33,700 "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 10 contains the largest share (9,567, or 28%) of simulation pools (conditional, technically recoverable BOE resources) for play 4. Pool size class 10 ranges from 16 to 32 Mmboe. The largest simulation pool for play 4 falls within pool size class 15, which ranges in size from 512 to 1,024 Mmboe (or 2.9 to 5.8 Tcfg). [Table 6](#) reports statistics for the simulation pools developed in the *GRASP* computer model for play 4.

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

Basin: Lower Cook Inlet
 Play Number: 4
 Play UAI Number: AAAAACAE

Assessor: Comer / Larson
 Play Name: Tertiary Gas Play

Date: March, 2005

Play Area (mi²; millions of acres): 825 (0.528)
 Reservoir Thermal Maturity, % Ro:

Play Depth Range, feet: 3,000 - 4,000 - 6,000
 Expected Oil Gravity, ° API: Gas Play / minor condensate
 Play Water Depth Range, feet: 50 - 150 - 200
 Prospect Distance from shore, miles: 25

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 | 0 | | | | 0.4 | --- | | | | 0.75 | | | ~ |
| Prospect Area (acres)-Model Output | 400 | 1727 | 2155 | 3118 | 4700 | 5656.0 / 3786.5 | 7085 | 8831 | 10252 | 12788 | 16401 | 19360 | 20000 |
| Fill Fraction (Fraction of Area Filled) | 0.2 | 0.21 | 0.25 | 0.31 | 0.4 | 0.4303 / 0.17064 | 0.52 | 0.59 | 0.65 | 0.75 | 0.88 | 0.97 | 1 |
| Productive Area of Pool (acres) | 104 | 542 | 722 | 1168 | 1994 | 2699.86 / 2315.16 | 3403 | 4533 | 5505 | 7342 | 10152 | 12599 | 14067 |
| Pay Thickness (feet) | 19 | 48 | 57 | 74 | 100 | 110.674 / 52.868 | 135 | 159 | 177 | 208 | 250 | 282 | 526 |

MPRO Module (Numbers of Pools)

| | | | | | |
|-------------------|------|-----------------------|-----|--------------------|-------|
| Play Level Chance | 0.75 | Prospect Level Chance | 0.3 | Exploration Chance | 0.225 |
|-------------------|------|-----------------------|-----|--------------------|-------|

| | | | |
|------------|-------------|--------------------------|-----------------|
| Risk Model | Play Chance | Petroleum System Factors | Prospect Chance |
| | | | |
| | | [See Risking Sheet] | |
| | | | |
| | | | |

| Fractile | F100 | F95 | F90 | F75 | F50 | Mean / Std. Dev. | F25 | F15 | F10 | F05 | F02 | F01 | F00 |
|------------------------------|------|-----|------------|---------|-----|------------------|-----|-----|-----|-----|-----|-----|-----|
| Numbers of Prospects in Play | 6 | 8 | 9 | 11 | 14 | 14.98 / 4.66 | 17 | 19 | 21 | 23 | 26 | 27 | 28 |
| Numbers of Pools in Play | ~ | ~ | F74.01 = 0 | F70 = 1 | 3 | 3.37 / 2.76 | 5 | 6 | 7 | 8 | 9 | 10 | 18 |

| | | | | | |
|-------------------------|---|----------------------|------|-------------------------|----|
| Minimum Number of Pools | 0 | Mean Number of Pools | 3.37 | Maximum Number of Pools | 18 |
|-------------------------|---|----------------------|------|-------------------------|----|

POOLS/PSRK/PSUM Module (Play Resources)

| Fractile | F100 | F95 | F90 | F75 | F50 | Mean / Std. Dev. | F25 | F15 | F10 | F05 | F02 | F01 | F00 |
|--------------------------------------|-------|-------|-------|-------|-------|-------------------|------|------|------|-------|-------|-------|-------|
| Oil Recovery Factor (bbl/acre-foot) | 153 | 234 | 252 | 286 | 328 | 334.954 / 70.119 | 376 | 405 | 426 | 459 | 499 | 528 | 700 |
| Gas Recovery Factor (Mcfg/acre-foot) | 375 | 556 | 594 | 663 | 750 | 762.558 / 141.960 | 848 | 906 | 947 | 1012 | 1090 | 1145 | 1476 |
| Gas Oil Ratio (Sol'n Gas)(cf/bbl) | 143 | 193 | 220 | 274 | 350 | 374.603 / 142.092 | 447 | 510 | 558 | 637 | 739 | 815 | 1110 |
| Condensate Yield ((bbl/Mmcfg) | 0.006 | 0.007 | 0.008 | 0.008 | 0.009 | 0.009 / 0.001 | 0.01 | 0.01 | 0.01 | 0.011 | 0.011 | 0.012 | 0.014 |

Pool Size Distribution Statistics from POOLS (1,000 BOE): μ (mu) = 10.1854428 σ^2 (sigma squared) = 0.866147680 Random Number Generator Seed = 166860

| | | | |
|----------------------------------|------|---|-----|
| BOE Conversion Factor (cf/bbl) | 5620 | Probability Any Pool Contains Both Oil and Free Gas (Gas Cap) | 0 |
| Probability Any Pool is 100% Oil | 0 | Fraction of Pool Volume Gas-Bearing in Oil Pools with Gas Cap | N/A |
| Probability Any Pool is 100% Gas | 1 | | |

Table 3. Input data for Cook Inlet play 4, 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: AAAACAE | Play No. 4 |
| World Level - | World Level Resources |
| Country Level - | UNITED STATES OF AMERICA |
| Region Level - | MMS - ALASKA REGION |
| Basin Level - | COOK INLET |
| Play Level - | 4 Tertiary - Gas |
| Geologist J. Larson | / D. Comer |
| Remarks 2005 Assessment | |
| Run Date & Time: Date | 19-Sep-05 Time 13:59:53 |

Summary of Play Potential

| Product | MEAN | Standard Deviation |
|---|---------|--------------------|
| BOE (Mboe) | 136,480 | 138,200 |
| Oil (Mbo) | 0 | 0 |
| Condensate (Mbc) | 7 | 7 |
| Free (Gas Cap & Nonassociated) Gas (Mmcfg) | 766,990 | 776,650 |
| Solution Gas (Mmcfg) | 0 | 0 |

10000 (Number of Trials in Sample)
0.7399 (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 | 31,240 | 0 | 2 | 175,560 | 0 |
| 65 | 53,262 | 0 | 3 | 299,320 | 0 |
| 60 | 71,357 | 0 | 4 | 401,000 | 0 |
| 55 | 89,717 | 0 | 5 | 504,190 | 0 |
| 50 | 107,680 | 0 | 6 | 605,130 | 0 |
| 45 | 124,640 | 0 | 6 | 700,470 | 0 |
| 40 | 143,950 | 0 | 7 | 808,970 | 0 |
| 35 | 165,260 | 0 | 8 | 928,720 | 0 |
| 30 | 187,870 | 0 | 10 | 1,055,800 | 0 |
| 25 | 211,780 | 0 | 11 | 1,190,100 | 0 |
| 20 | 241,280 | 0 | 12 | 1,355,900 | 0 |
| 15 | 275,930 | 0 | 14 | 1,550,600 | 0 |
| 10 | 324,850 | 0 | 16 | 1,825,600 | 0 |
| 8 | 347,350 | 0 | 18 | 1,952,000 | 0 |
| 6 | 380,980 | 0 | 19 | 2,141,000 | 0 |
| 5 | 399,820 | 0 | 20 | 2,246,900 | 0 |
| 4 | 422,200 | 0 | 21 | 2,372,600 | 0 |
| 2 | 499,520 | 0 | 26 | 2,807,200 | 0 |
| 1 | 583,300 | 0 | 30 | 3,278,000 | 0 |
| 0.1 | 798,770 | 0 | 45 | 4,488,800 | 0 |
| 0.01 | 987,750 | 0 | 45 | 5,550,900 | 0 |
| 0.001 | 1,051,000 | 0 | 56 | 5,906,500 | 0 |

Table 5. Assessment results by commodity for Cook Inlet play 4, 2006 assessment.

| Basin: COOK INLET Play 04 - Tertiary - Gas UAI Key: AAAAACAE | | | | Model Simulation "Pools" Reported by "Fieldsiz.out" GRASP Module | | | | | | | | | | | | | | | | | |
|--|-------------|-------------|------------|--|---------------|-------------------|------------------|----------|----------|------------------|-----|----------------|-----|----------------|-----|------------------|-----|----------------------------------|------------|----------------|------------------|
| Classification and Size | | | | Pool Count Statistics | | | Pool Types Count | | | Mixed Pool Range | | Oil Pool Range | | Gas Pool Range | | Total Pool Range | | Pool Resource Statistics (MMBOE) | | | |
| Class | Min (MMBOE) | Max (MMBOE) | Pool Count | Percentage | Trial Average | Trials w/Pool Avg | Mixed Pool | Oil Pool | Gas Pool | Min | Max | Min | Max | Min | Max | Min | Max | Min | 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 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| 3 | 0.125 | 0.25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| 4 | 0.25 | 0.5 | 1 | 0.002967 | 0.0001 | 0.000135 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0.499099 | 0.499099 | 0.499099 | 499.098510 |
| 5 | 0.5 | 1 | 10 | 0.029674 | 0.001 | 0.001351 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0.713797 | 0.978524 | 8.754361 | 875.436068 |
| 6 | 1 | 2 | 89 | 0.264095 | 0.0089 | 0.012027 | 0 | 0 | 89 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 1 | 1.023280 | 1.999405 | 142.479266 | 1.600891 |
| 7 | 2 | 4 | 645 | 1.913947 | 0.0645 | 0.087162 | 0 | 0 | 645 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 1 | 2.000604 | 3.999189 | 2008.861000 | 3.114514 |
| 8 | 4 | 8 | 2581 | 7.658754 | 0.2581 | 0.348784 | 0 | 0 | 2581 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 1 | 4.000019 | 7.996652 | 15980.863000 | 6.191733 |
| 9 | 8 | 16 | 6545 | 19.421366 | 0.6545 | 0.884459 | 0 | 0 | 6545 | 0 | 0 | 0 | 0 | 0 | 1 | 6 | 1 | 8.001179 | 15.998145 | 78295.848000 | 11.962696 |
| 10 | 16 | 32 | 9597 | 28.477745 | 0.9597 | 1.296892 | 0 | 0 | 9597 | 0 | 0 | 0 | 0 | 0 | 1 | 7 | 1 | 16.004958 | 31.993032 | 223053.529000 | 23.242006 |
| 11 | 32 | 64 | 8438 | 25.038576 | 0.8438 | 1.14027 | 0 | 0 | 8438 | 0 | 0 | 0 | 0 | 0 | 1 | 7 | 1 | 32.000118 | 63.992310 | 381095.958000 | 45.164253 |
| 12 | 64 | 128 | 4247 | 12.602374 | 0.4247 | 0.573919 | 0 | 0 | 4247 | 0 | 0 | 0 | 0 | 0 | 1 | 5 | 1 | 64.027549 | 127.995933 | 371504.421000 | 87.474548 |
| 13 | 128 | 256 | 1358 | 4.029674 | 0.1358 | 0.183514 | 0 | 0 | 1358 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 1 | 128.011595 | 255.333567 | 230034.060000 | 169.391800 |
| 14 | 256 | 512 | 179 | 0.531157 | 0.0179 | 0.024189 | 0 | 0 | 179 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 256.155067 | 495.520810 | 56482.429000 | 315.544281 |
| 15 | 512 | 1024 | 10 | 0.029674 | 0.001 | 0.001351 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 519.601438 | 904.642310 | 6208.238000 | 620.823792 |
| 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 | | | | | | | | | | | Below Class | | | 0.000000 |
| Totals | | | 33700 | 99.999992 | 3.37 | 4.554054 | Above Class | | | | | | | | | | | Above Class | | | 0.000000 |
| Number of Pools not Classified: 0 | | | | <div>Min and Max refer to numbers of pools of the relevant size class that occur within any single trial in the simulation.</div> <div>Min and Max refer to aggregate resources of the relevant size class that occur within any single trial in the simulation.</div> | | | | | | | | | | | | | | | | | |
| Number of Pools below Class 1: 0 | | | | | | | | | | | | | | | | | | | | | |
| Number of Trials with Pools: 7400 | | | | | | | | | | | | | | | | | | | | | |

Table 6. Statistics for simulation pools created in computer sampling run for Cook Inlet play 4, 2006 assessment.

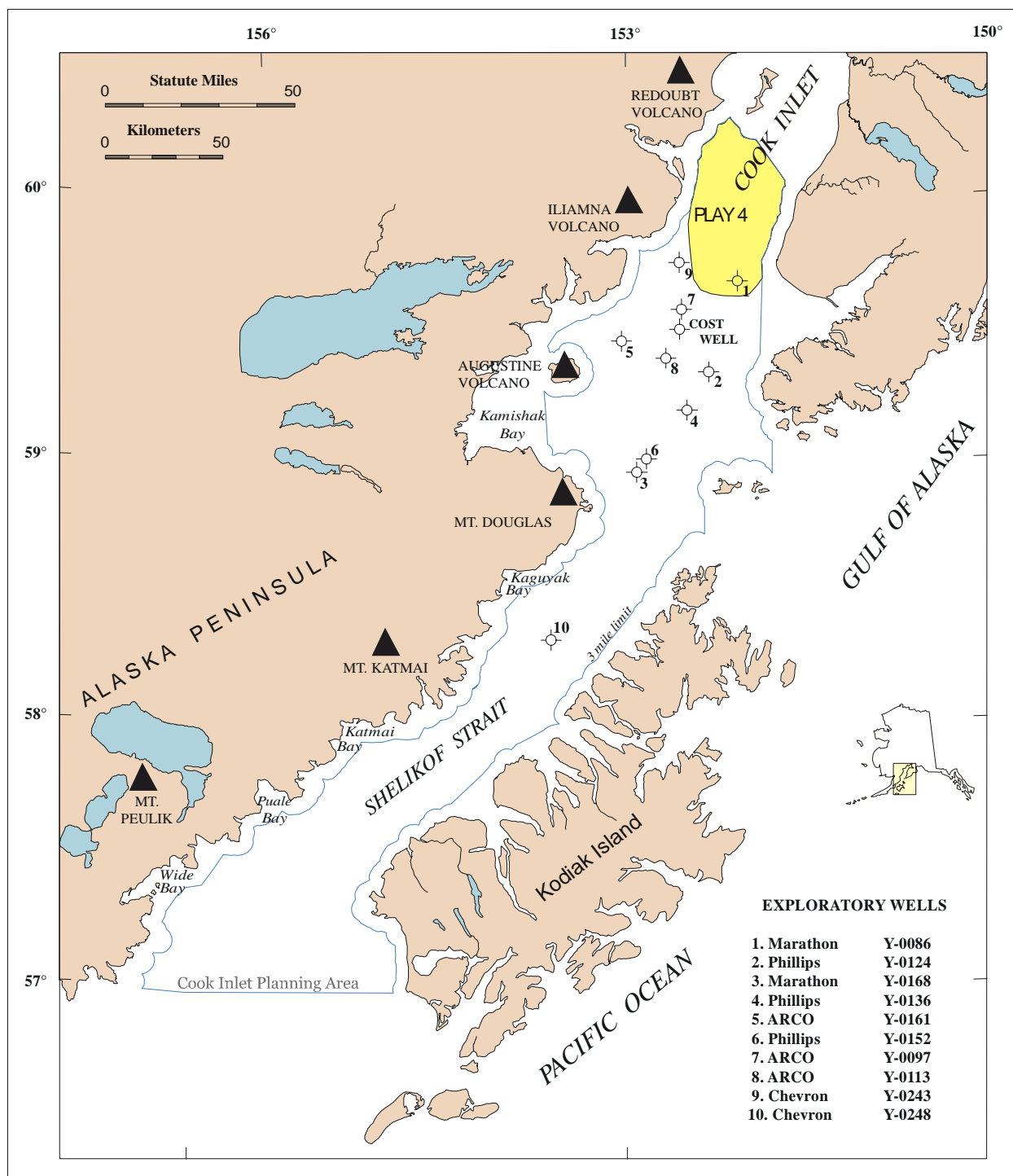


Figure 1. Map location of Cook Inlet play 4, 2006 assessment.