

Arctic Energy Office U.S. Department of Energy



Cook Inlet Resource Potential “Missing Fields” Gas (and Oil) Distribution/Endowment A Log-Normal Perspective

South Central Alaska Energy Forum
Sept. 20-21, 2006

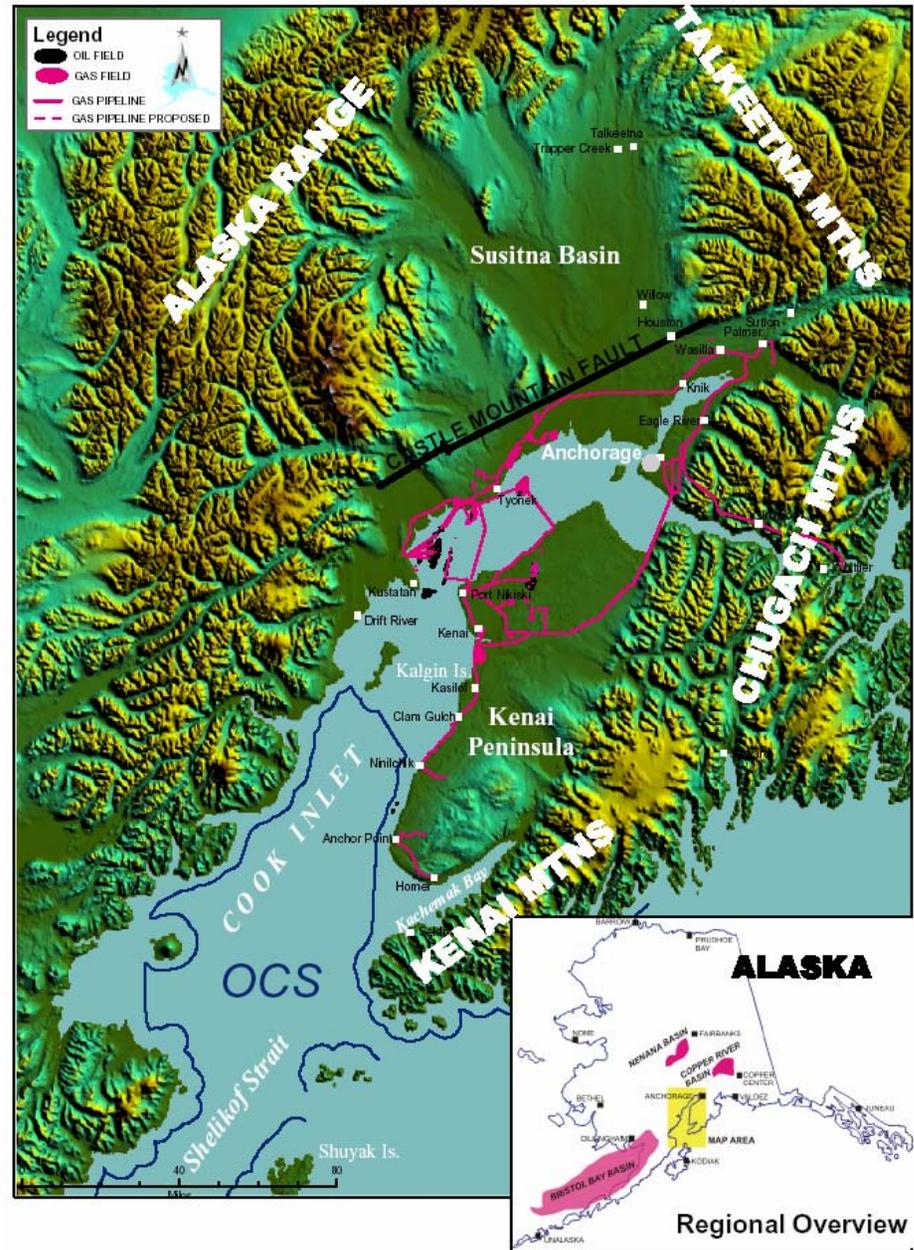
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South Central Alaska Geological Setting

- Basin Subdivided Into Upper Cook Inlet, Lower Cook Inlet and Susitna Basin
- Emphasis On Upper Cook Inlet



- Oil-prone Source Rocks Of Late Triassic And Middle Jurassic
- Oil/Associated Gas In Lower Tertiary
- Gas Source Rocks Associated With Coals Of Upper Tertiary
- Non-associated Gas In Upper Tertiary

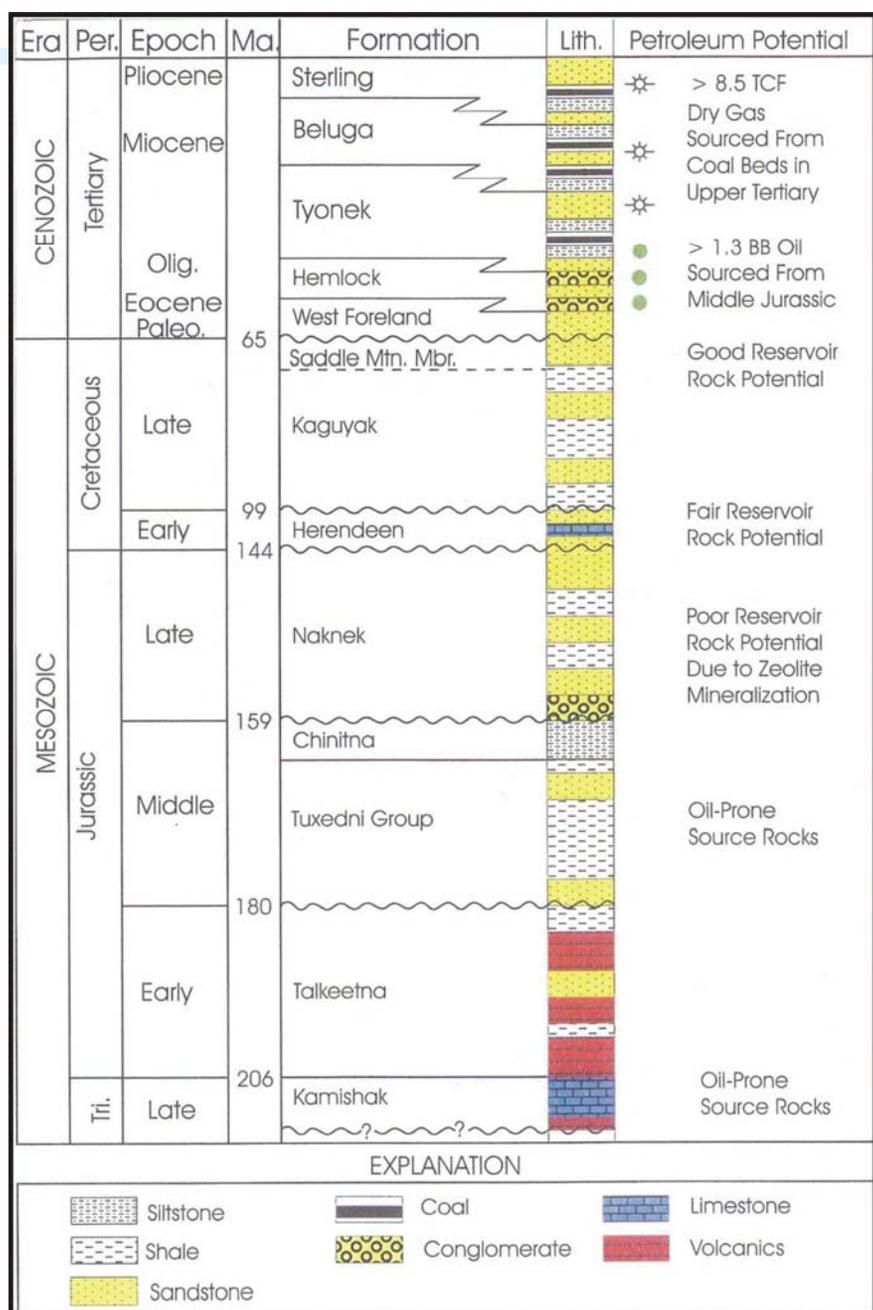


FIGURE 5. COOK INLET BASIN, ALASKA
Stratigraphic Column - Oil and Gas Reservoir Intervals

- **Approximately 220 Exploration Wells In Upper Cook Inlet**
- **13 Wells In Federal OCS – Not On Map**
- **9 Wells In Susitna Basin – Not All Are Shown On The Map**
- **Does Not Include CBM Wells**

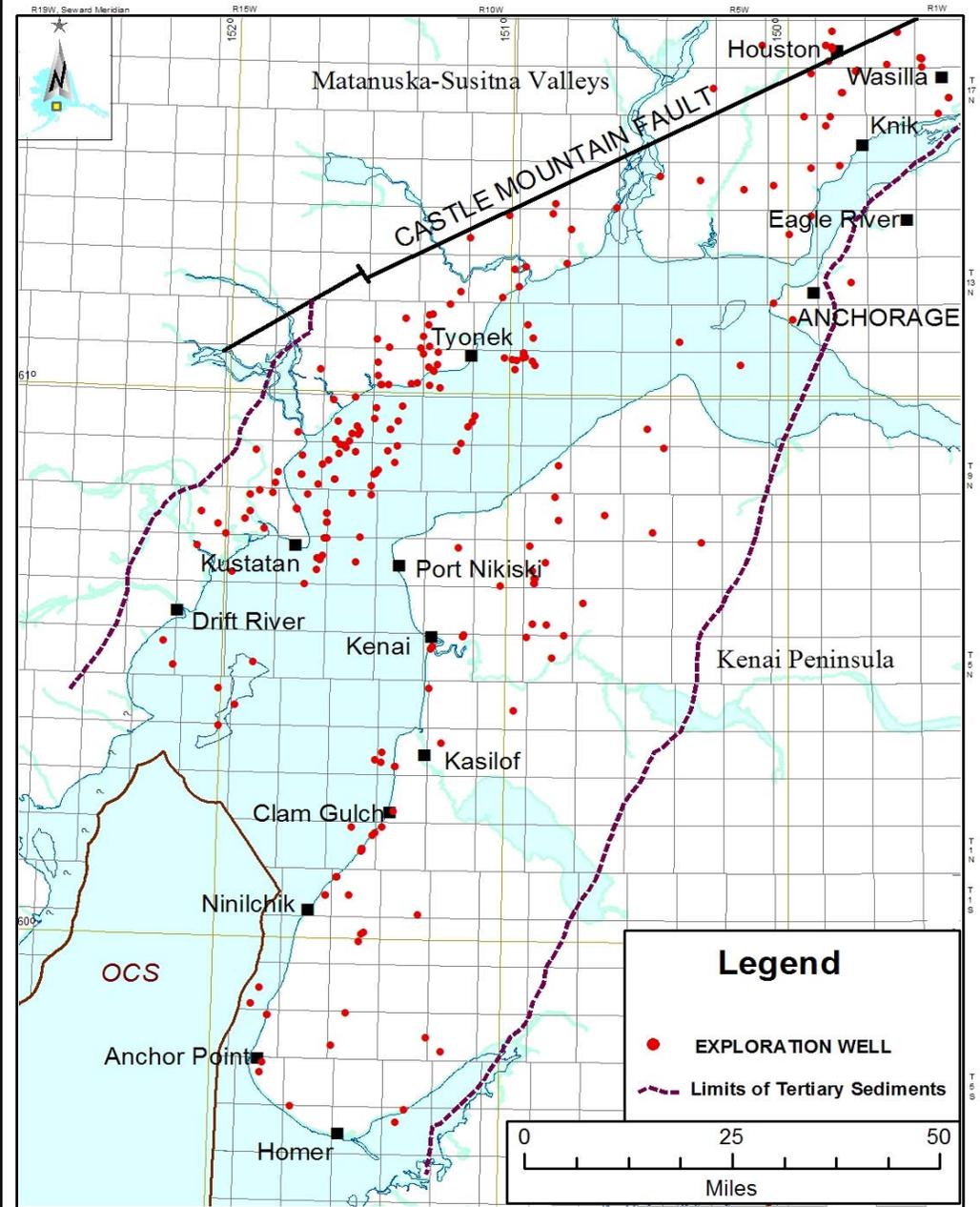


FIGURE 4. COOK INLET BASIN, ALASKA

EXPLORATION WELLS 1955 - 2003

OIL & GAS EXPLORATION AND FIELD DISCOVERIES IN COOK INLET 1955-2003

TIME PERIOD	EXPL. WELLS DRILLED	GAS FIELDS DISCOVERED	SUCCESS RATIO (%)	EST. ULTIMATE REC. (Bcf)
1955-60	17	5	29.4	2,603.50
1961-65	42	9	21.4	3,575.23
1966-70	85	6	7.1	1,814.86
1971-75	29	1	3.4	10.86
1976-80	14	1	7.1	8.19
1981-85	13	0	0.0	0.00
1986-90	5	0	0.0	0.00
1991-95	11	2	18.2	139.78
1996-00	10	3	30.0	151.72
2001-03	14	1	7.1	100.00(?)
TOTAL	240	28	11.7	8,404.14

TIME PERIOD	EXPL. WELLS DRILLED	Oil FIELDS DISCOVERED	SUCCESS RATIO (%)	EST. ULTIMATE REC. (MMbo)
1955-60	17	1	5.9	233.0
1961-65	42	4	9.5	1101.0
1966-70	85	1	1.2	6.0
1971-75	29	1	3.4	6.0
1976-80	14	0	0.0	0/0
1981-85	13	0	0.0	0.0
1986-90	5	0	0.0	0.0
1991-95	11	1	9.1	14..0
1996-00	10	0	0.0	0.0
2001-03	14	0	0.0	0.0
TOTAL	240	8	3.3	1,360.0

- 240 Exploration Wells
- Exploration Activity Decreased Over Time
- Virtually All Fields Found By 1970
- All Exploration Until Mid-90s Was For Oil
- Recent Activity (Last Five Years) Has Focused On Gas
- **Approximately 10 Tcf OGIP, 8.5 Tcf EUR**
- **Approximately 3.7 Bbo OOIP, 1.36 Bbo EUR**

- Oil and Gas Fields
- 28 Gas Accumulations
- 8 Oil Accumulations
- Two Distinct NNE Trends
- Associated With Anticlines

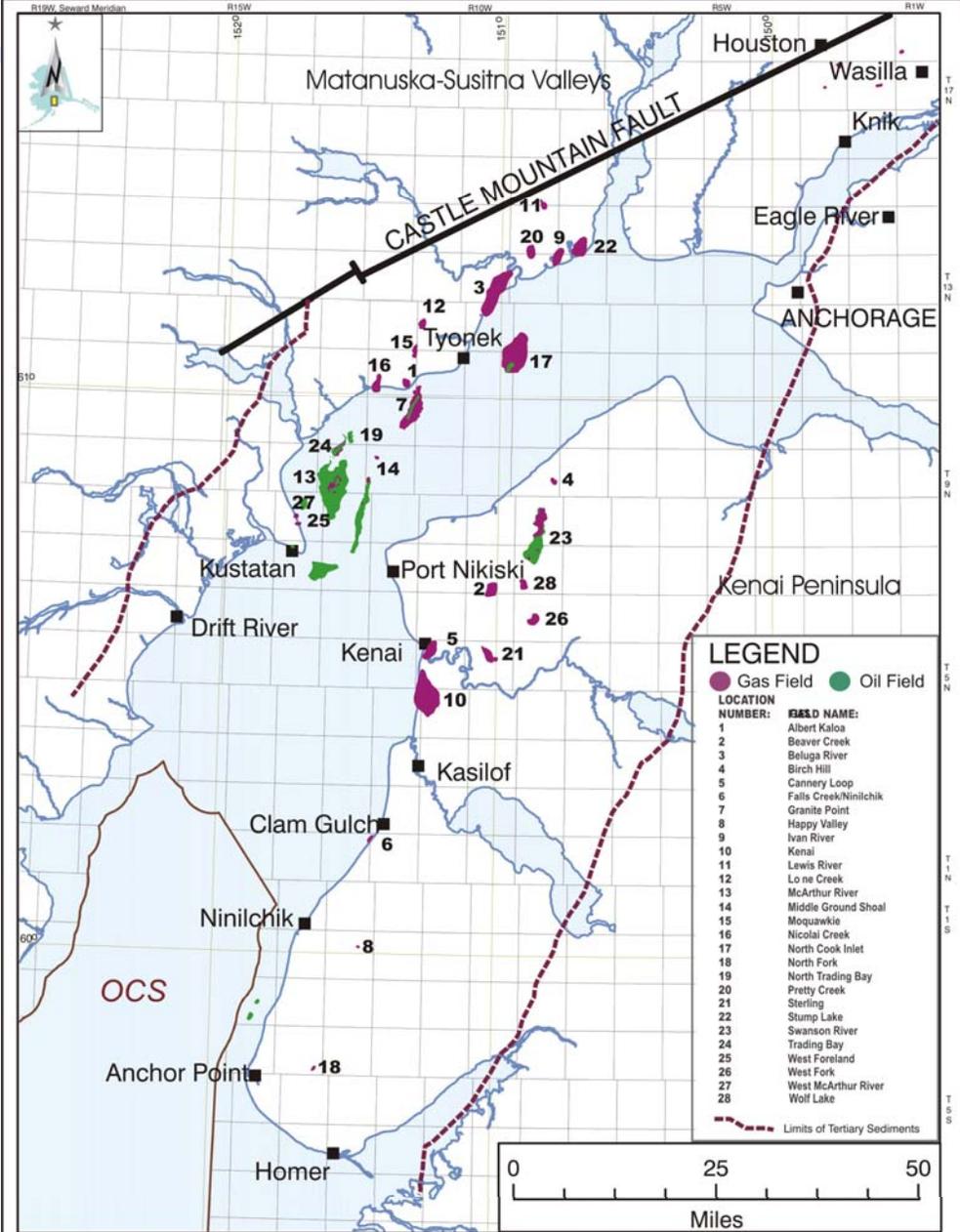


FIGURE 6. COOK INLET BASIN, ALASKA

OIL AND GAS FIELDS

GENERAL CHARACTERISTICS OF COOK INLET NATURAL GAS/FIELDS

- **GAS ORIGIN – 94% IS NON ASSOCIATED BIOGENIC GAS; 6% IS ASSOCIATED THERMOGENIC GAS**
- **RESERVOIRS – STERLING = 57%; BELUGA = 14%; TYONEK = 25%; HEMLOCK/WEST FORELAND ASSOCIATED GAS = 4%**
- **GAS FIELDS – AOGCC REPORTS PRODUCTION FROM 29 FIELDS**
- **FIELD SIZE – THREE LARGE FIELDS (KENAI, BELUGA, NORTH COOK INLET) ACCOUNT FOR APPROXIMATELY 80% OF EUR**
- **FIELD SIZE DISTRIBUTION – USING USGS FIELD CLASS SIZES THERE ARE “HOLES” IN THE FIELD SIZE DISTRIBUTION (MISSING FIELDS)**

LOG-NORMAL DISTRIBUTION OF HYDROCARBON ACCUMULATIONS, COOK INLET, ALASKA

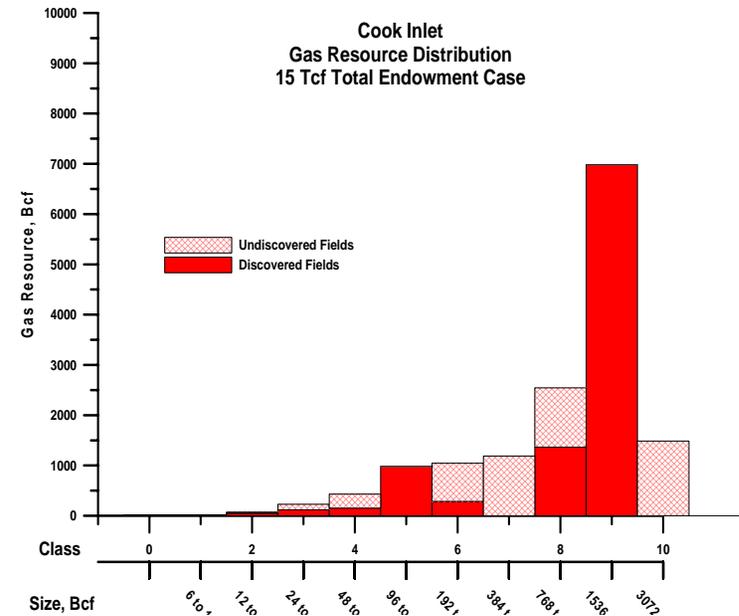
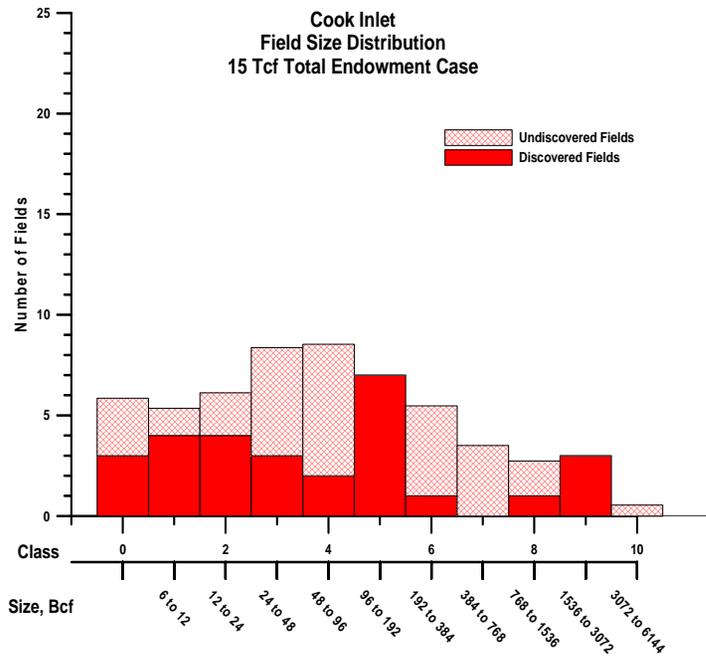
- **THE SIZE OF OIL AND GAS FIELDS WITHIN BASINS HAVE A LOG-NORMAL DISTRIBUTION**
- **DISCOVERED FIELDS IN COOK INLET DO NOT CONFORM TO A LOG-NORMAL DISTRIBUTION**
- **THE LACK OF LOG-NORMALITY IN THE GAS FIELD SIZE DISTRIBUTION WAS EXAMINED IN A DOE REPORT – “SOUTH-CENTRAL ALASKA NATURAL GAS STUDY”**
- **THE LEVEL OF GAS ENDOWMENT IN THE BASIN NECESSARY TO ACHIEVE LOG-NORMAL STATUS WAS TESTED**
- **OIL WAS NOT INCLUDED IN THE EARLIER STUDY, BUT WAS BRIEFLY EXAMINED FOR THE PURPOSE OF THIS REPORT.**

USGS field class size distribution

Number of fields and OGIP/class Size in Cook Inlet.

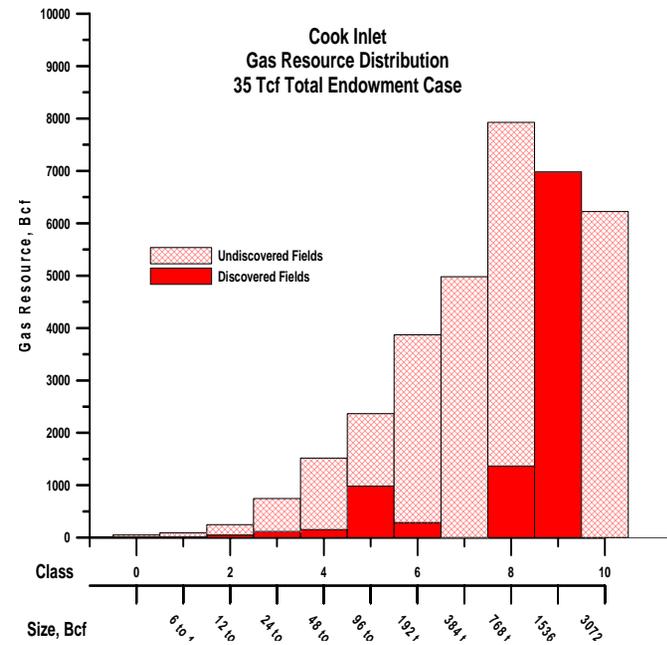
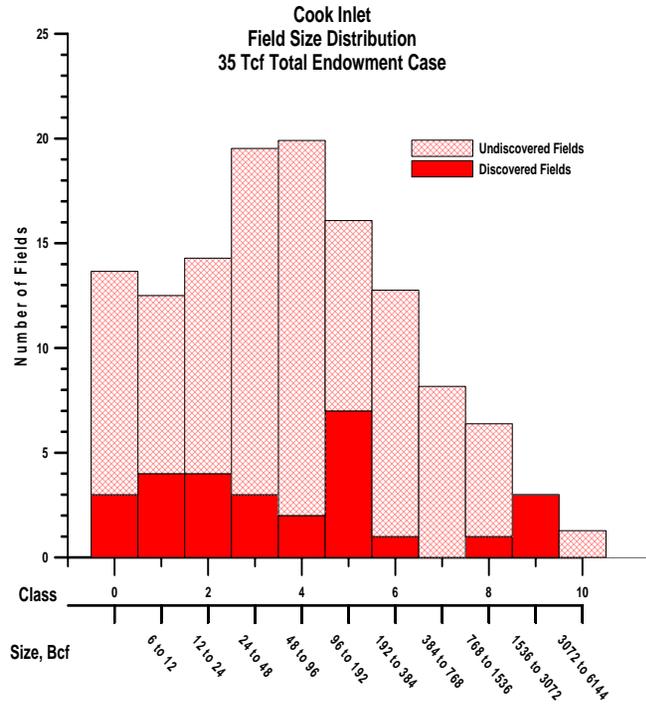
	SIZE - OGIP (BCF)	DISCOVERED FIELDS	DISCOVERED OGIP (TCF)
Class 0	< 6.0	3	Trace
Class 1	6.0-12.0	4	Trace
Class 2	12.0-24.0	4	<0.1
Class 3	24.0-48.0	3	~0.1
Class 4	48.0-96.0	2	~0.15
Class 5	96.0-192.0	7	1.0
Class 6	192.0-384.0	1	0.2
Class 7	384.0-768.0	0	0.0
Class 8	768.0-1,536.0	1	1.3
Class 9	1,536.0-3,072.0	3	7.0
Class 10	3,072.0-6,144.0	0	0.0

COOK INLET - 15 Tcf ENDOWMENT



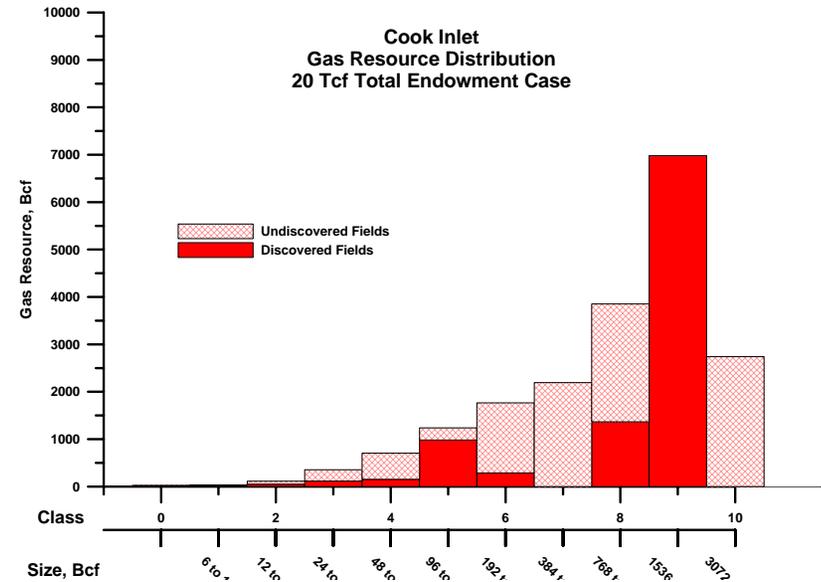
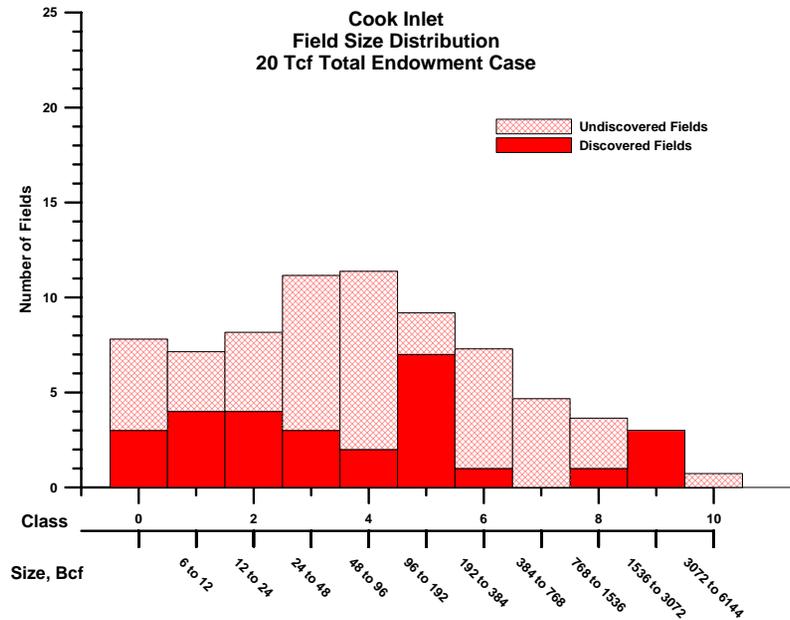
- Left = Number of Fields/Class for Endowment Value
- Right = Gas Resource/Class for Endowment Value
- Log Normal Distribution is Expected Case
- 15 Tcf is Insufficient:
 - Endowment = Known Reserves Plus Reserve Growth/ Not Enough Class 6 to 8 Fields

Cook Inlet - 35 Tcf Endowment



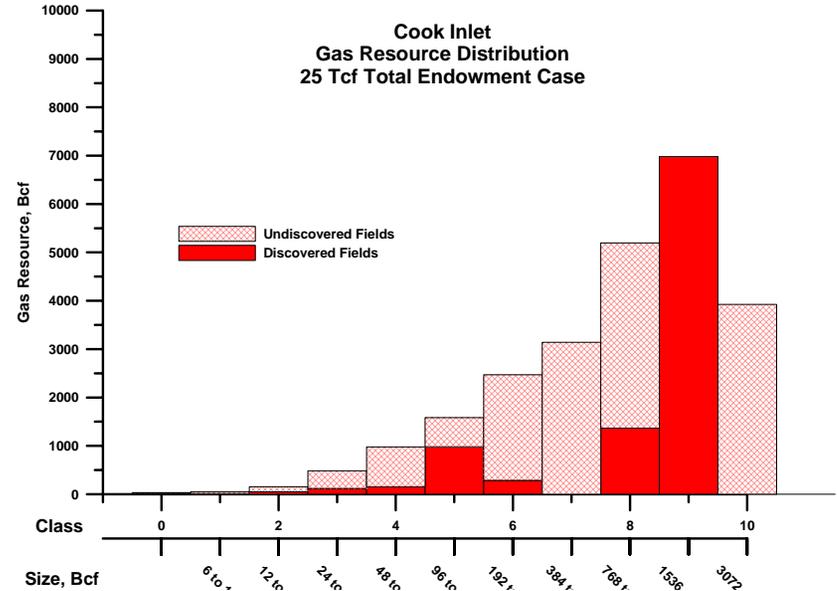
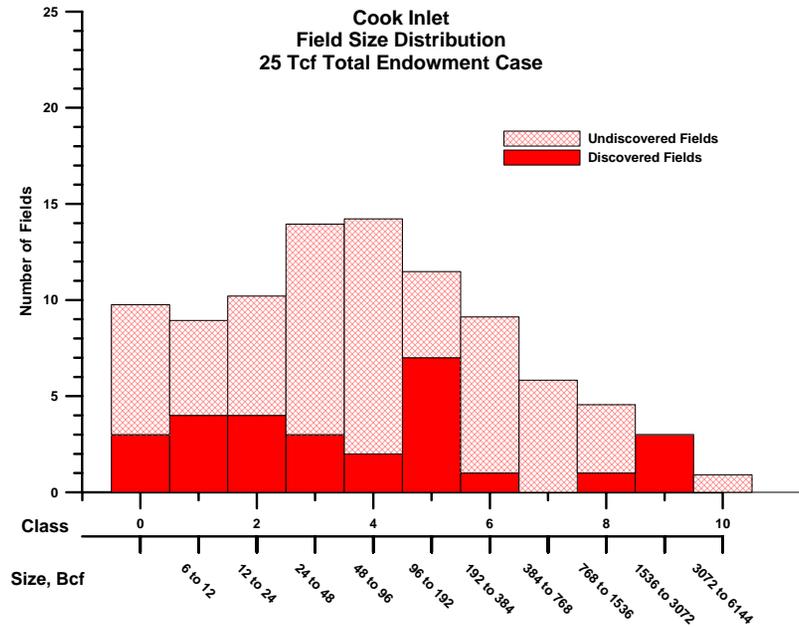
- 35 Tcf Appears Too Large
- Large Number of Missing Fields In Classes 6-8 (24)
- Possible Stratigraphic Traps
- 15 Tcf And 35 Tcf Appear To Bracket The Endowment

Cook Inlet - 20 Tcf Endowment



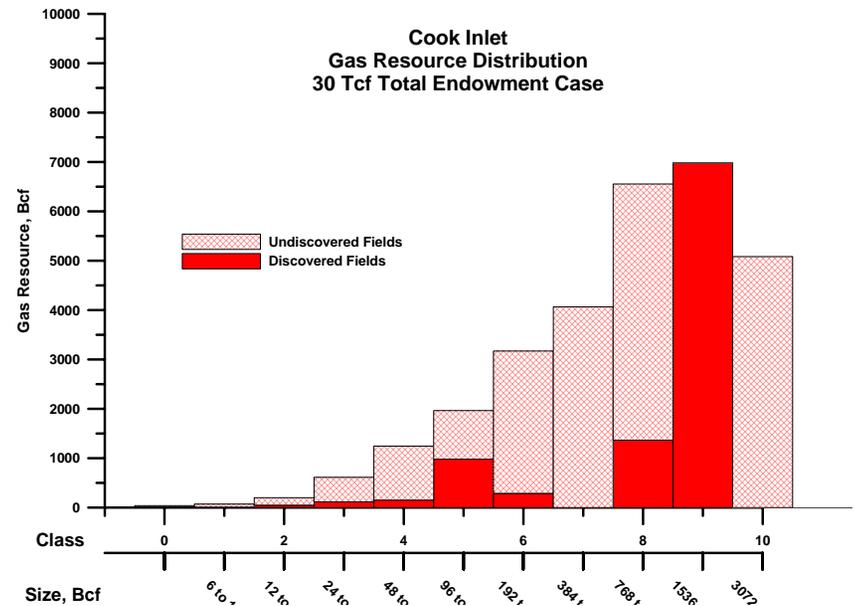
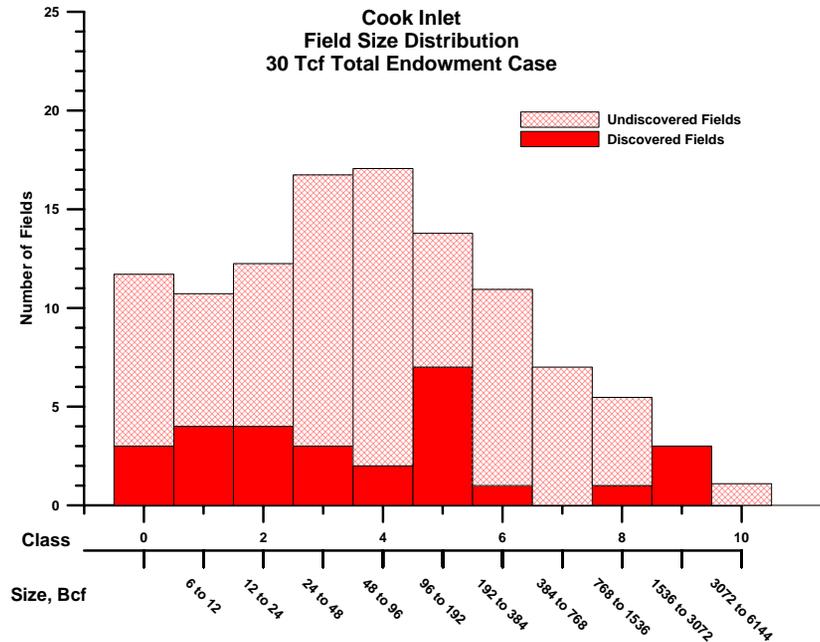
- Like 15 Tcf – Inadequate Number of Fields in Classes 6-8
- Great Bulk of Reserves are in 2 Classes

Cook Inlet – 25 Tcf Endowment



- 25 Tcf Has Good Fit For Both Number of Fields and Resource Distribution

Cook Inlet – 30 Tcf Endowment



- 30 Tcf also has a Good Fit
- Basin endowment is estimated to be between 25 and 30 Tcf OGIP
 - Analysis does not provide any evidence on where the fields will be located in the basin

Distribution of Undiscovered Gas Resources by USGS Class Size in Five Possible Gas Endowment Scenarios – Cook Inlet Alaska

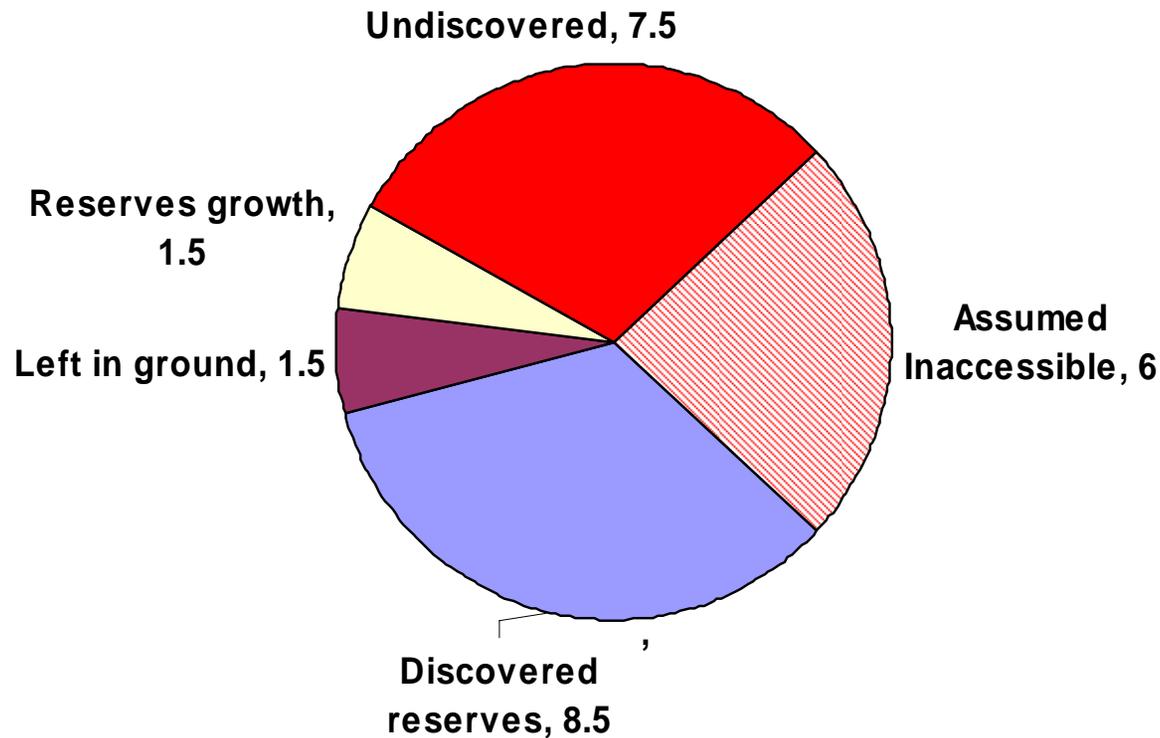
Gas Endowment OGIP (Tcf)	Undiscovered Fields by Class Size				Undiscovered OGIP by Class Size (Bcf) ¹				Undiscovered Conventionally Recoverable Resources by Class Size (Bcf) ²			
	Class Size range	3-5	6-8	10	Total	3-5	6-8	10	Total	3-5	6-8	10
15.0	11	9	0	20	450	3,200	NA	5,000	380	2,700	NA	3,100
20.0	19	14	1	34	1,000	6,100	2,800	10,000	850	5,180	2,380	8,400
25.0	28	17	1	46	1,700	9,200	4,000	15,000	1,450	7,820	3,400	12,700
30.0	34	21	1	56	2,700	12,000	5,000	20,000	2,300	10,200	4,250	16,750
35.0	43	24	1	68	3,300	14,000	6,000	25,000	2,800	11,900	5,100	19,800

1.Total represents the volume of the gas endowment minus the OGIP in the known fields.

2.Total represents the sum of the undiscovered conventionally recoverable resources distributed among classes 3 to 10.

25 Tcf Conventional Gas Endowment

Cook Inlet Gas Endowment



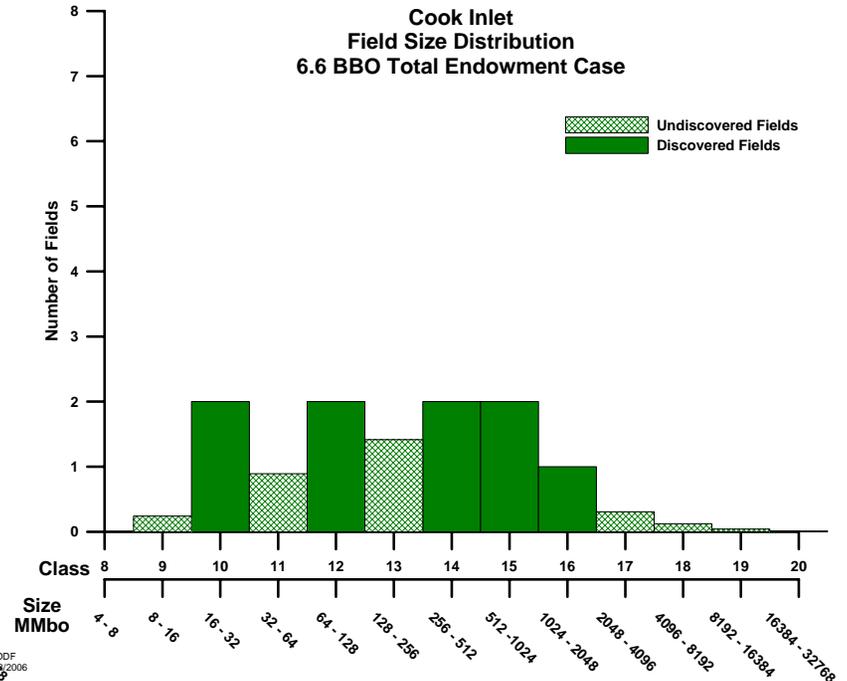
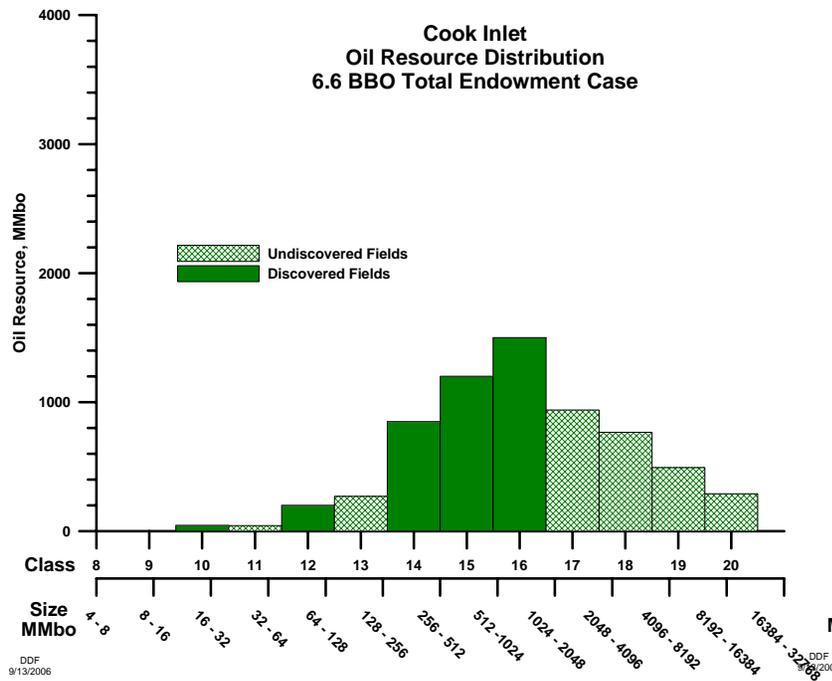
USGS OIL FIELD CLASS SIZE CATAGORIES

USGS FIELD CLASS SIZE CATAGORIES	
Class	Oil field size (Millions barrels)
1	0.03125 - 0.0625
2	0.0625 - 0.125
3	0.125 - 0.25
4	0.25 - 0.5
5	0.5 - 1
6	1 - 2
7	2 - 4
8	4 - 8
9	8 - 16
10	16 - 32
11	32 - 64
12	64 - 128
13	128 - 256
14	256 - 512
15	512 - 1024
16	1024 - 2048
17	2048 - 4096
18	4096 - 8192
19	8192 - 16384
20	16384 - 32768

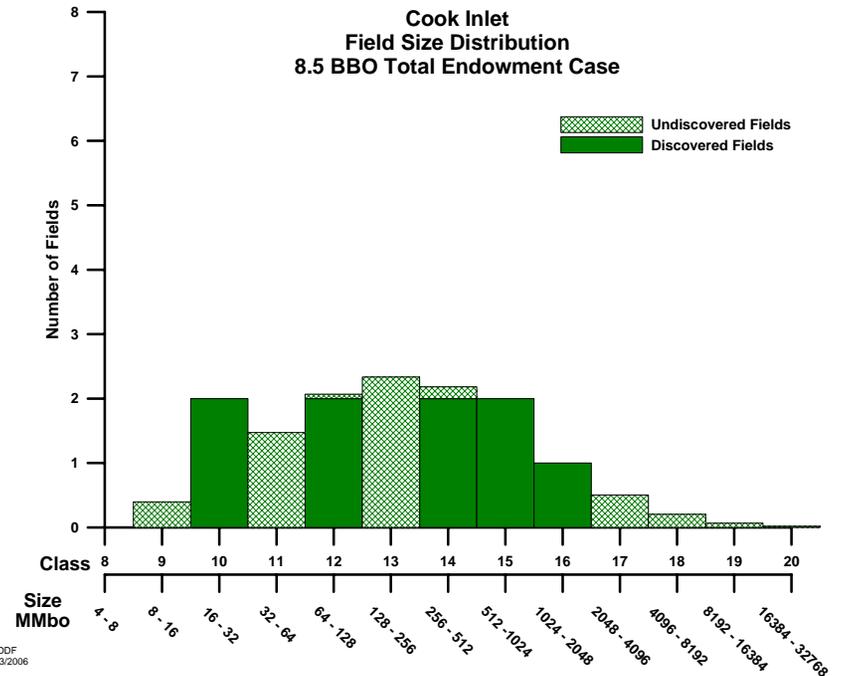
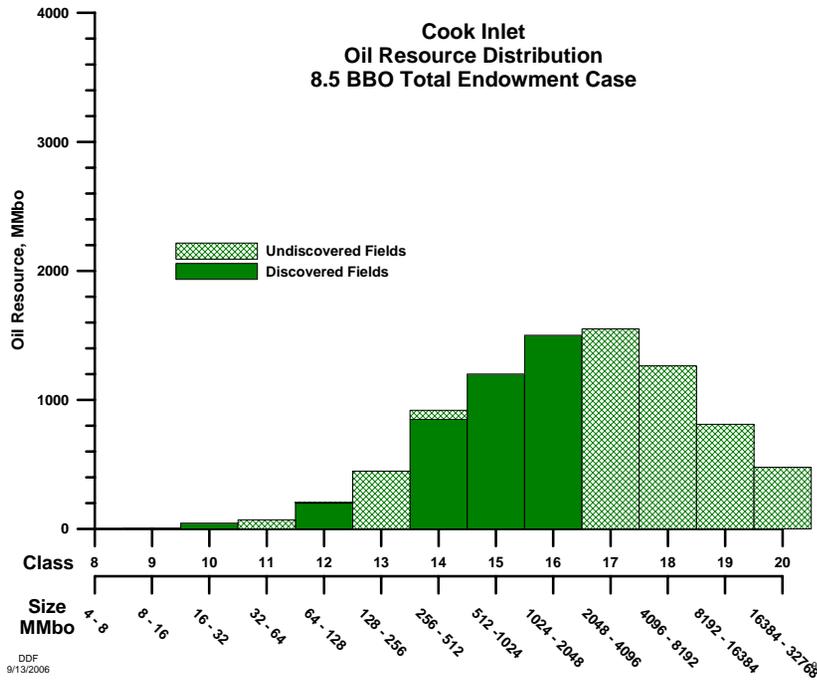
Cook Inlet Oil Fields

Class Size	NAME	MMbo	MMbo	recovery factor
		OOIP	cum 12/31/2005	
10	Beaver Creek	24.3	5.788	
10	Redoubt Shoal	20	1.833	0.092
12	North Trading Bay Unit	100	23.703	0.237
12	West MacArthur River	100	11.005	0.110
14	Trading Bay	350	78.649	0.225
14	Swanson River	500	230.4	0.461
15	Granite Point	600	143.01	0.238
15	Middle Ground Shoal	600	193.047	0.322
16	MacArthur River	1,500	630.975	0.421
	Total	3794.3	1318.4	0.347

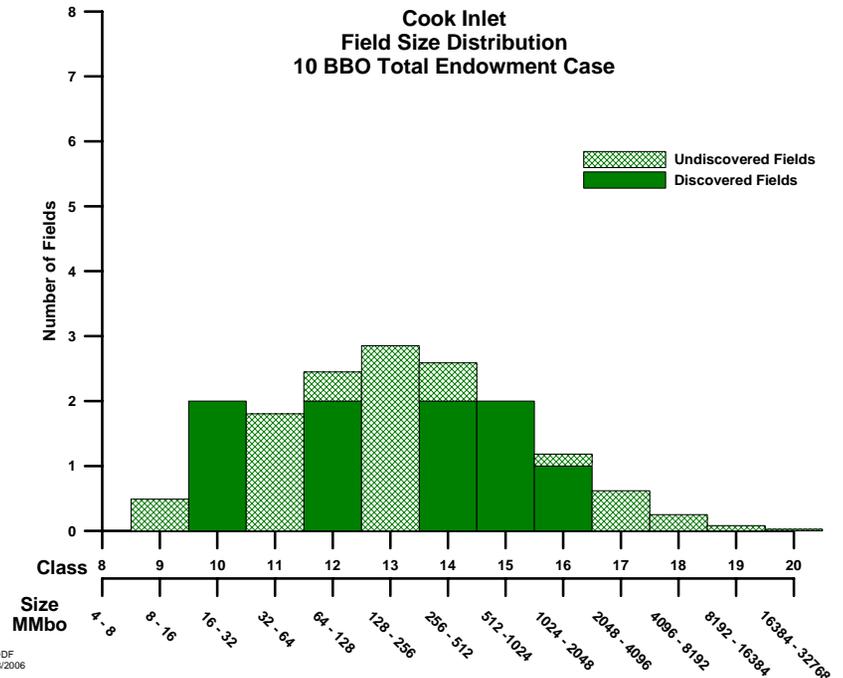
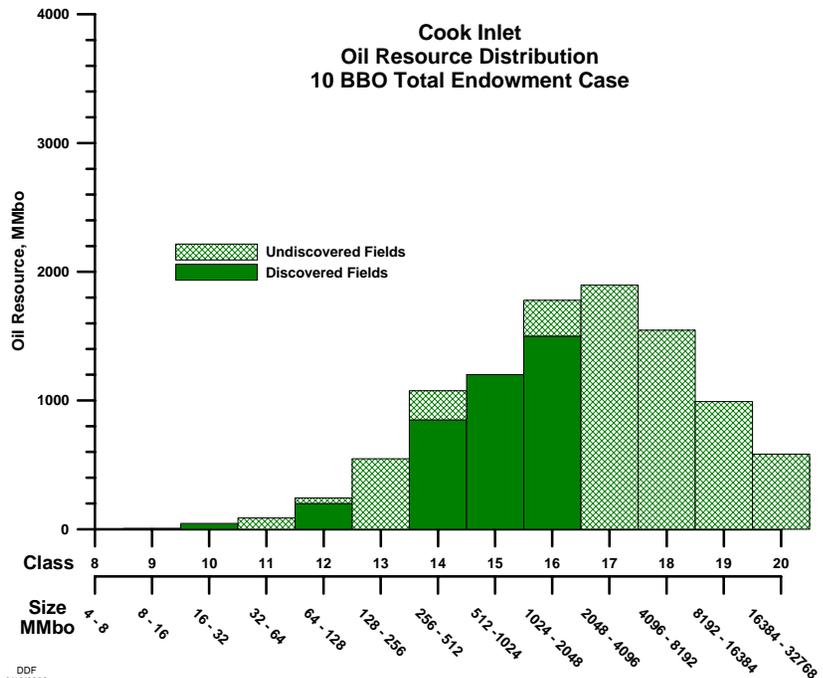
Cook Inlet – 6.6 BBO Endowment



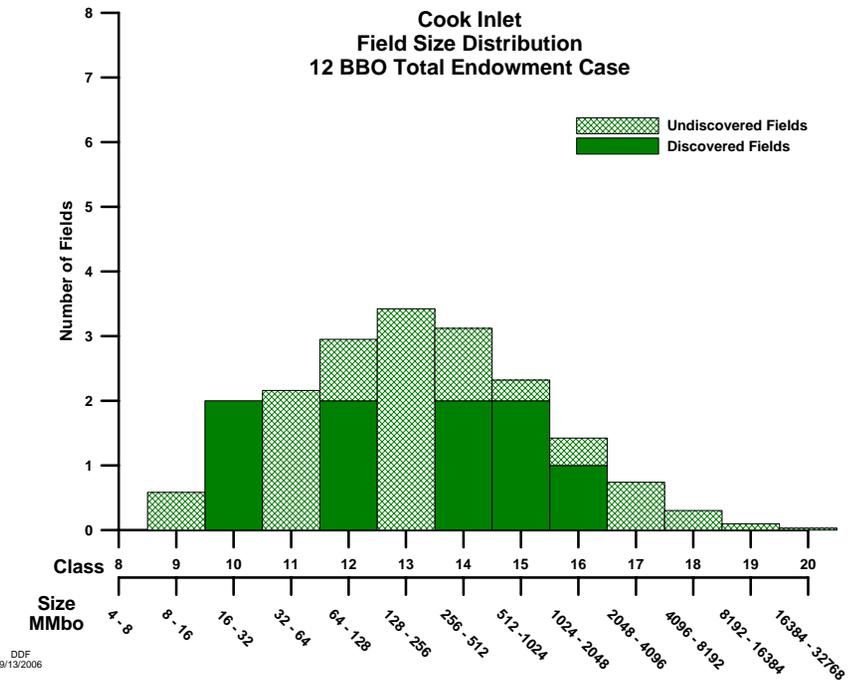
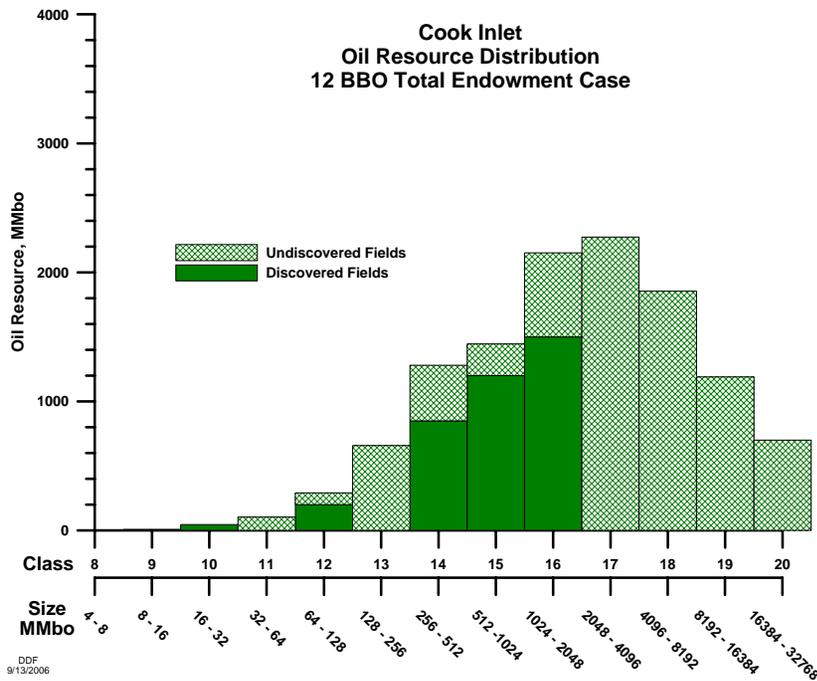
Cook Inlet – 8.5 BBO Endowment



Cook Inlet – 10 BBO Endowment



Cook Inlet – 12 BBO Endowment



Distribution of Undiscovered Oil Resources by USGS Class Size in Four Possible Oil Endowment Scenarios – Cook Inlet Alaska

Oil Endowment OGIP (MMBO)	Undiscovered Fields by Class Size				Undiscovered OOIP by Class Size (MMBO) ¹			
	Class Size Range	9-12	13-16	17-20	Total	9-12	13-16	17-20
6.6	1	2	1	4	50	250	2,500	2,800
8.5	2	2	1	5	50	550	4,100	4,700
10.0	3	4	1	8	100	1,100	5,000	6,200
12.0	3	5	1	9	200	2,000	6,000	8,200

¹ Total represents the volume of the oil endowment minus the OOIP in the known fields.

Geology and Resource Base Summary & Conclusions

- **Historically exploration has been for oil**
 - Virtually all gas has been found by “accident”
 - Prior to 1970
- **All exploration has been for structural plays**
 - probably as much gas, or more, left to be found in stratigraphic plays
- **Non-associated biogenic gas comprises 94 % of produced gas and is the objective in future exploration**
- **The current fields have about 8.5 Tcf of EUR or represent about 10.0 Tcf OGIP**
 - Probably only a fraction of the basin’s potential
- **Number of fields and field size are expected to be log-normal distributions**
 - there are missing fields in the range of 200 Bcf to 1.5 Tcf OGIP

Summary and Conclusions, Cont.

- Oil exploration has been focused on seismically well-defined anticlinal features with no evaluation of the multitude of stratigraphic or combined traps developed within the basin.
- The known producing oil fields have EUR of about 1.36 Bbo and 3.70 Bb OOIP.
- The various endowments (OOIP) strongly suggest that there remains at least as much undiscovered oil in the basin as has been discovered. The oil may be in structures off-limits to industry, stratigraphic/combination traps, or in largely unexplored and under-evaluated Mesozoic reservoirs.
- As with the gas fields, the oil field size should be a log-normal distribution, the picture is not as clear-cut as with gas but there are fields missing in the 128-256, 32-64, and possibly in the greater than 2,048 MMbo range.
- To better understand the additional potential of the basin, in terms of the stratigraphic aspects of oil and gas accumulations, the DGGs is undertaking a study of the upper Cook Inlet. That effort was initiated this summer by David LePain.

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Announcements

GOM Hydrates JIP/DOE Drilling Data & Hydrate Tool & Protocol Development Workshop - This workshop will be held April 13th & 14th in Houston, Texas and is open to JIP members and others interested in the latest developments in the commercialization of naturally occurring gas hydrates. [Visit the workshop website for more information.](#)

New Natural Gas & Oil Funding Opportunities - There are four open solicitations targeting: Methane Hydrates; Advanced Detection and Imaging of Low Permeability Gas Formations; High Pressure and High Temperature Drilling; and Enhanced Oil and Gas Production through CO2 Injection. [NETL Solicitation Page](#)

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