Does It Pay to Innovate? An Economic Lookback at the Lifecycle of the Amplitude Play of the Deepwater GOM with Application to other Trends*

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Abstract

The exploration frontier is characterized by the intersection of resource access, technological barriers, and profitability. To develop insight into the most profitable time to enter a play from a technological barrier standpoint, full-cycle economic valuations were performed on 105 producing fields from the deepwater amplitude play (DWAMP) in the Gulf of Mexico. The fields were originally identified as “bright spots” in greater than 1000 ft. water depth between 1974 and 2008. Key technologies such as the floating production platform, subsea production equipment, and 3D seismic were invented in the 1970's, but were either inaccessibly expensive or untested in deep water and served as play entry barriers. The net present value (NPV) and internal rate of return (IRR) were calculated using publicly available leasing, drilling, production, and facilities information. To provide the best estimate of intrinsic profitability, all economic valuations were run at a common commodity price deck and cost index. The novelty of this study is that we use economic results to generate value-based creaming curves. Results of the analysis demonstrate there are unique economic distributions as a function of play entry timing and show in what context discovered resources relate to value. The first mover group, defined as the first 5% of fields to come online, has the widest NPV distribution and the poorest overall performance, which is the consequence of producers moving into the play before the requisite technologies were available. The role of innovation in value generation is underscored by the fact that 80% of the play's NPV was generated on leases that were held before key production technologies like tension-leg and spar platforms were commercially available. Strategically, this suggests that it pays to speculate on imminent technology breakthroughs through early leasing in order to capture the most NPV from a play. Early adopters (first 5%-15%) capture the highest NPV, but later entrants (last 15%) capture the highest average and most narrowly distributed IRR. Subsea tie backs (SSTB) have a greater chance of exceeding the 10% IRR threshold. Regarding the future of exploration, the value creaming curve methodology described above is applied to the subsalt Miocene play and demonstrates great value potential remains with imaging being the technology barrier.

Theme 11: Previous Predictions and Future Trends
4/4/2017

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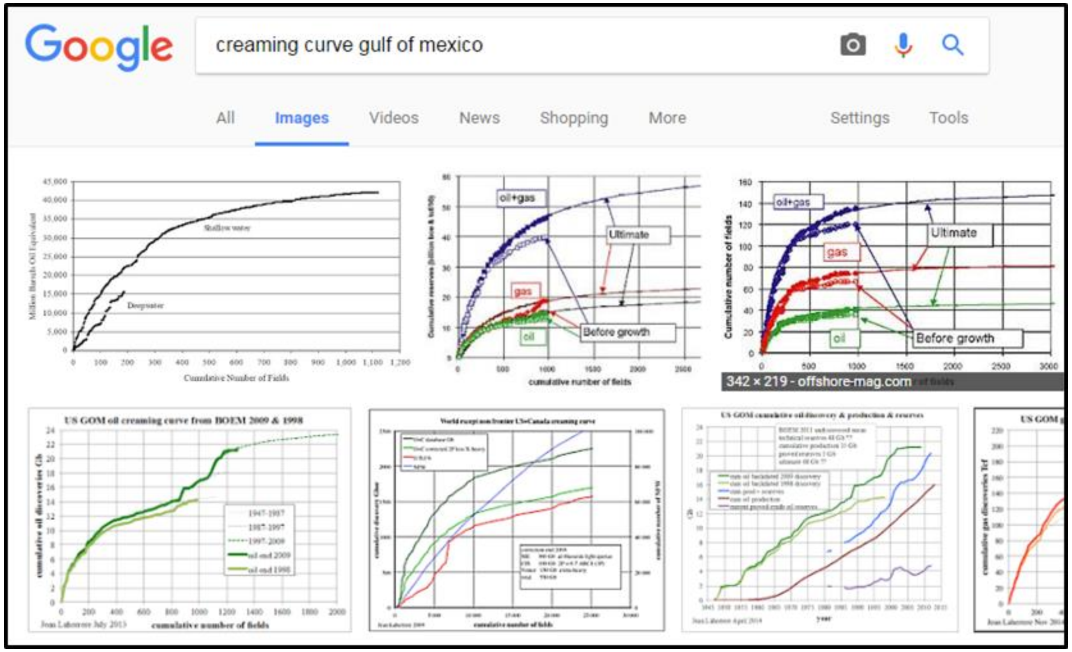
Not Another Creaming Curve Study

- Creaming Curve methodology established in 1981
- Demonstrates predictable pattern of declining field sizes with play maturity
- Demonstrates diminishing effectiveness of exploration but lacks insights
  - Impact of technology
  - The learning curve
  - Economic considerations
  - Strategy
- Who has actually used one?



Google Search for “Creaming Curves Gulf of Mexico”

- What does a play look like from a value perspective?
- When is the optimal time to enter a play? Prefer NPV, IRR?
- Aligning innovation strategy with business strategy?

An Economic Lookback at the Deepwater Amplitude Play

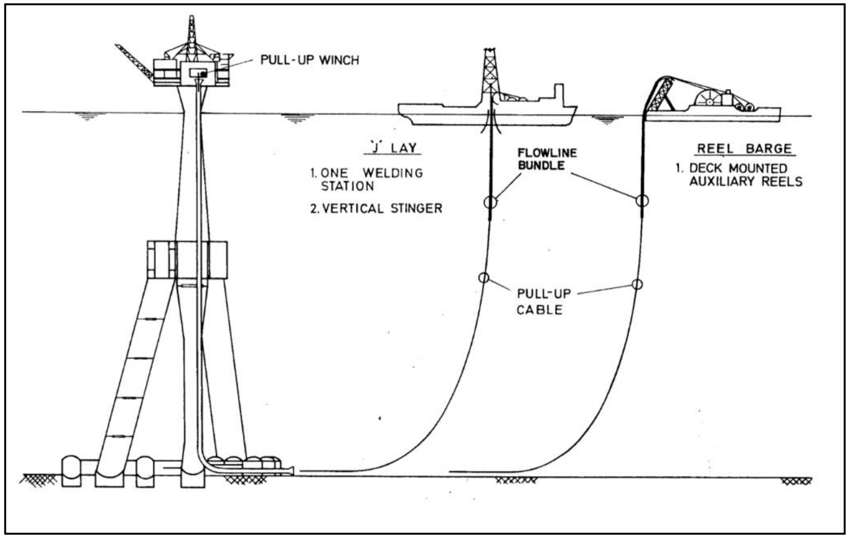
- **107 fields**
  - 1000+ ft. water
  - Originally identified as seismic “bright spots”, high chance of finding hydrocarbons
- **Play lifecycle 1974-2005, production through 2015**
- **Technologic Entry barriers**
  - Reservoir presence (predominance of fluvial-deltaics)
  - Exploration scale 3D seismic
  - Deepwater drilling (narrow margin, SWF’s...)
  - Production technology
    - Host facilities
    - Production risers, flexible pipe
    - Control systems, ROV’s
    - Subsea installation, intervention, flow assurance
  - Pre-1983 lease-block nomination scheme
- **Impact of 1983 area-wide leasing**
  - Extreme competition (record oil price)
  - Must land-grab before play is proven

Number	Field	Online
1	Cognac	1979
2	Lena	1984
3	Placid GC75	1988
4	Bullwinkle	1989
5	Jolliet	1989
6	Amberjack	1991
7	Alabaster	1992
8	Zinc	1993
9	Diamond-Oryx	1993
10	Auger	1994
11	Pompano	1994
12	Cooper	1995
13	VK862	1995
14	Southeast Tahoe	1996
15	Tahoe	1996
16	Popeye	1996
17	Rocky	1996
18	Mustique	1996
19	Mars	1996
20	Mensa	1997
21	Neptune-Kerr McGee	1997
22	Ram-Powell	1997
23	Troika	1997
24	Baldpate	1998
25	Morpeth	1998
26	Arnold	1998
27	Oyster	1998
28	Manta Ray	1999
29	Macaroni	1999
30	BST	1999
31	Ursa	1999
32	Penn State	1999
33	Allegheny	1999
34	Genesis	1999
35	Marlin	1999
36	Angus	1999
37	Dulcimer	1999
38	Virgo	1999
39	Diana	2000
40	Europa	2000
41	Hoover	2000
42	King	2000
43	Northwestern	2000
44	Black Widow	2000
45	Petronius	2000
46	King Kong	2001
47	Serrano	2001
48	Ladybug	2001
49	Nile	2001
50	Marshall	2001
51	Oregano	2001
52	Prince	2001
53	Boomvang West	2001
54	EW878	2001

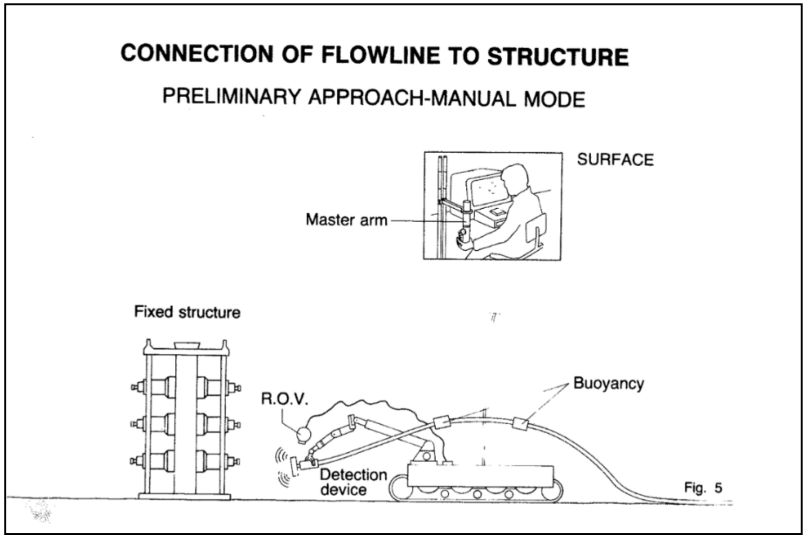
Number	Field	Online
55	MC68	2001
56	Navajo	2001
57	Brutus	2001
58	King's Peak	2002
59	King-Amoco	2002
60	Crosby	2002
61	Boomvang East	2002
62	Prosperity	2002
63	Boomvang	2002
64	Madison	2002
65	Horn Mountain	2002
66	Manatee	2002
67	Einset	2002
68	Aconcagua	2002
69	Nansen	2002
70	Camden Hills	2002
71	Sangria	2002
72	Princess	2002
73	Tulane	2002
74	Lost Ark	2002
75	GB205	2002
76	Diana South	2003
77	Zia	2003
78	Habanero	2003
79	Medusa	2003
80	Aspen	2003
81	Gunnison	2003
82	Matterhorn	2003
83	Boris	2003
84	Na Kika	2003
85	Falcon	2003
86	MC400	2003
87	Glider	2004
88	Llano	2004
89	Devil's Tower	2004
90	Front Runner	2004
91	Holstein	2004
92	Magnolia	2004
93	Marco Polo	2004
94	Loon	2004
95	Ochre	2004
96	Swordfish	2005
97	Gomez	2006
98	Rigel	2006
99	Constitution	2006
100	Seventeen Hands	2006
101	SW Horseshoe	2006
102	Ticonderoga	2006
103	Independence Hub	2007
104	Cottonwood	2007
105	Anduin	2007
106	Bass Lite	2008
107	Big Bend*	2015

*Big Bend added for comparison

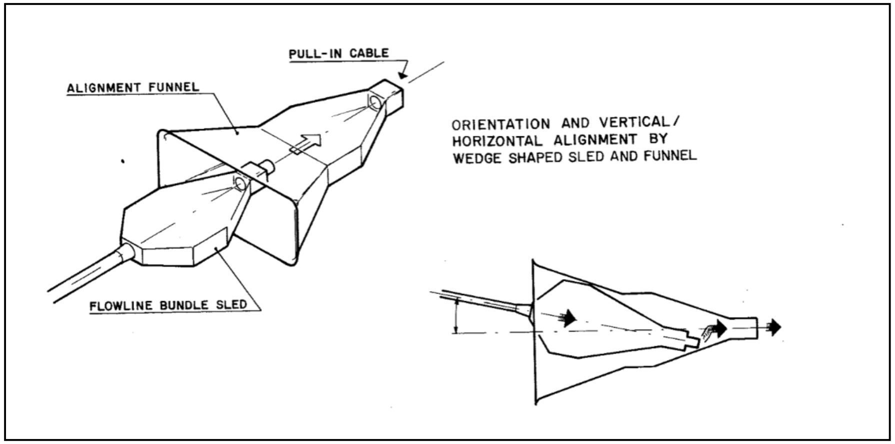
Deepwater Technological Barriers: Subsea Installation



Pipe welding and “J” lay



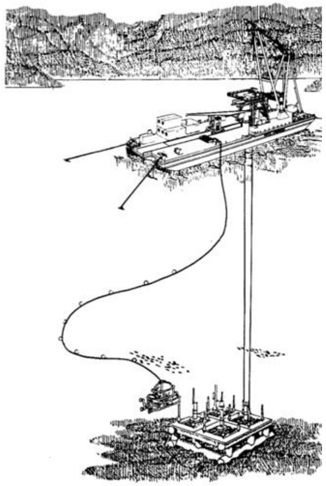
Flowline Connection



Flowline Connection

Deepwater Technological Barriers: Intervention/Maintenance

Fig. 2. NUTEC FJORDBASE
Displ. 2000 tdw
Length 65 m
Width 22 m
M. moonpool 8 x 10 m
Ext. moonpool 4 x 30 m
Sheerleg 200 t
Prop. 2 x 650 hp



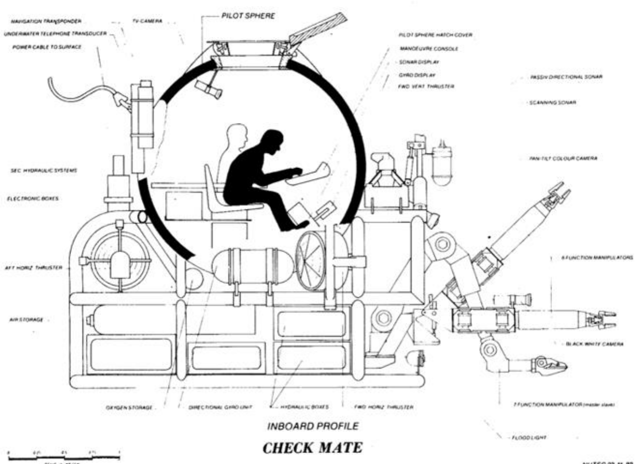
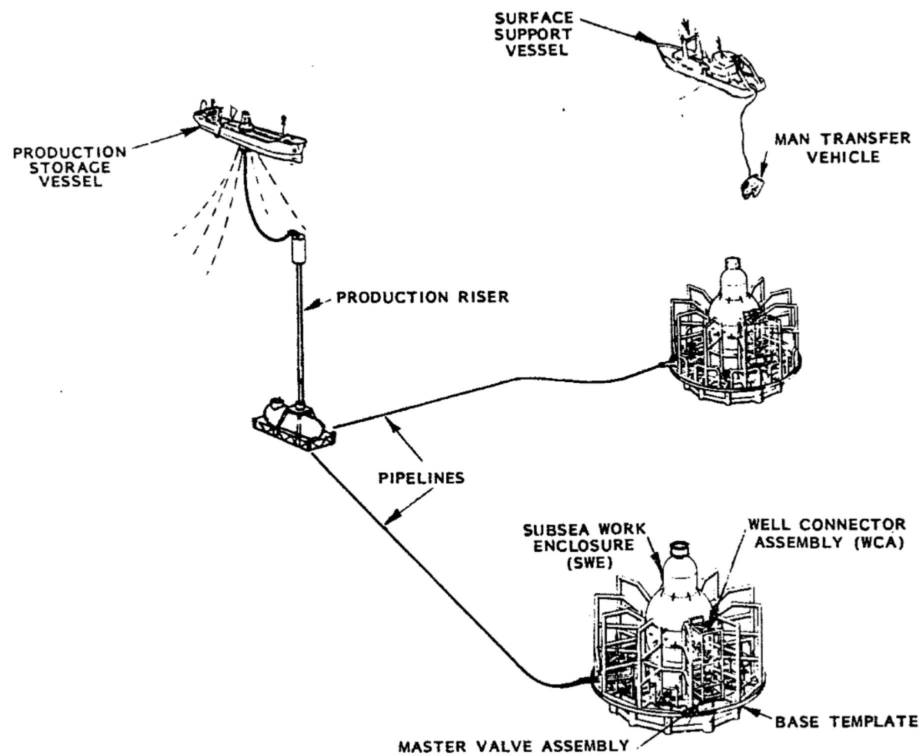


Fig. 3. The two-manned, multipurpose tethered submersible, Check-Mate.

Manned Submersible Prototype



Mobil's 1atm Subsea Chamber

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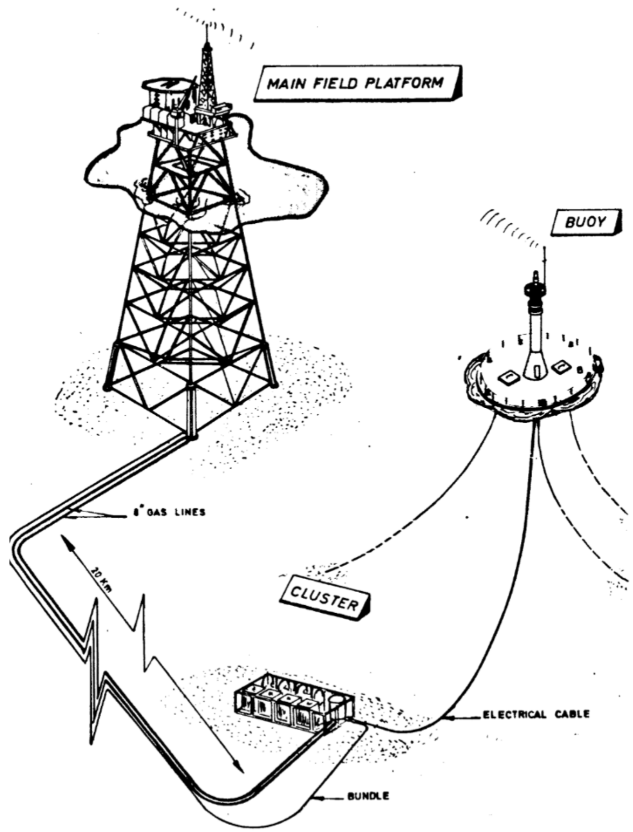
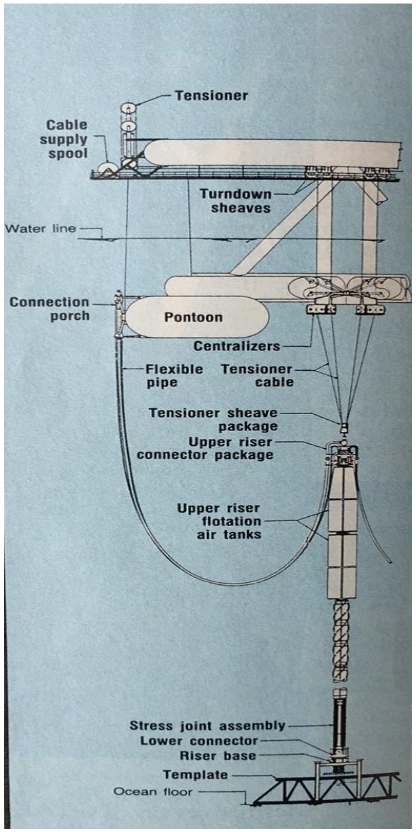
Deepwater Technological Barriers: Control Systems



Radio Buoy

Deepwater Technological Barriers: Risers



Rigid/Flexible Combo

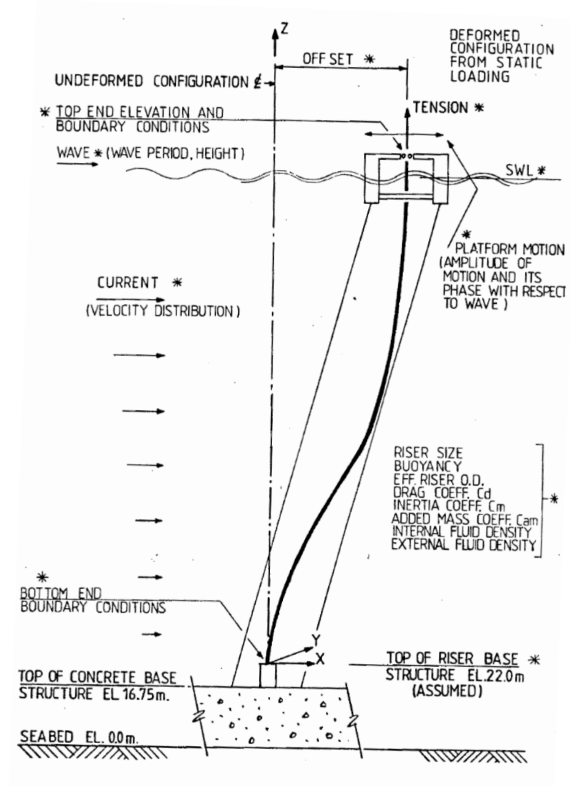
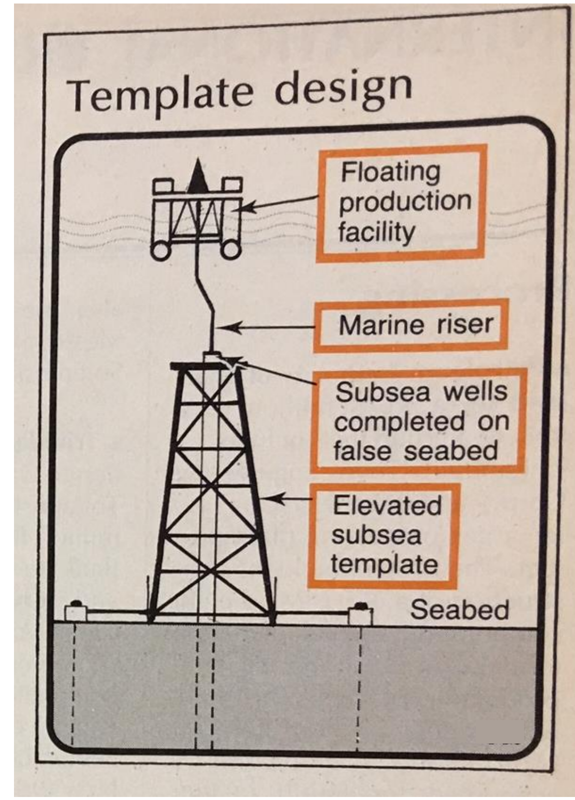


FIG. 11 RISER DESIGN PROCEDURE

Flexible



Elevated Template Idea

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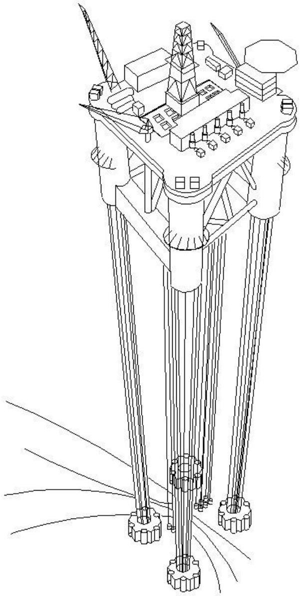
Deepwater Technological Barriers: Host Facilities


Compliant Tower (Lena)


Fixed Platform (Bullwinkle)


Floater (Penrod 72)


TLP (Jolliet)

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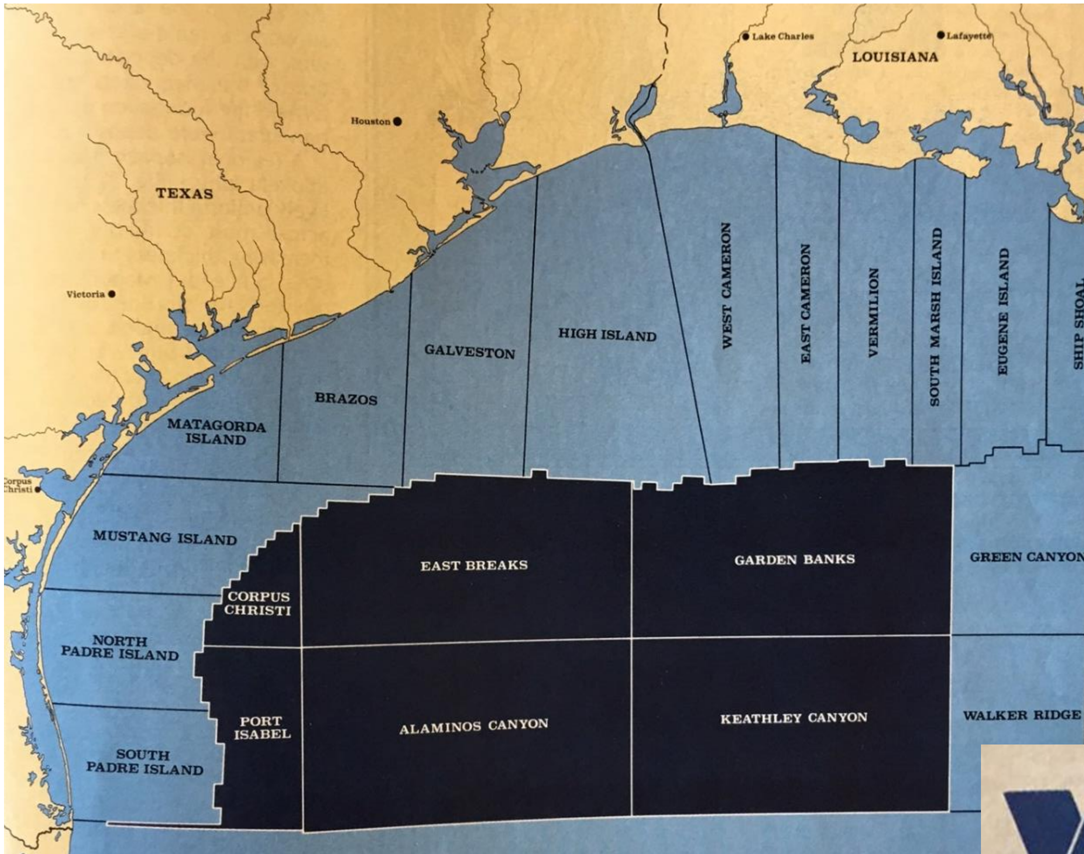
$160k/sqmi (1980) to $2k/sqmi (2000)

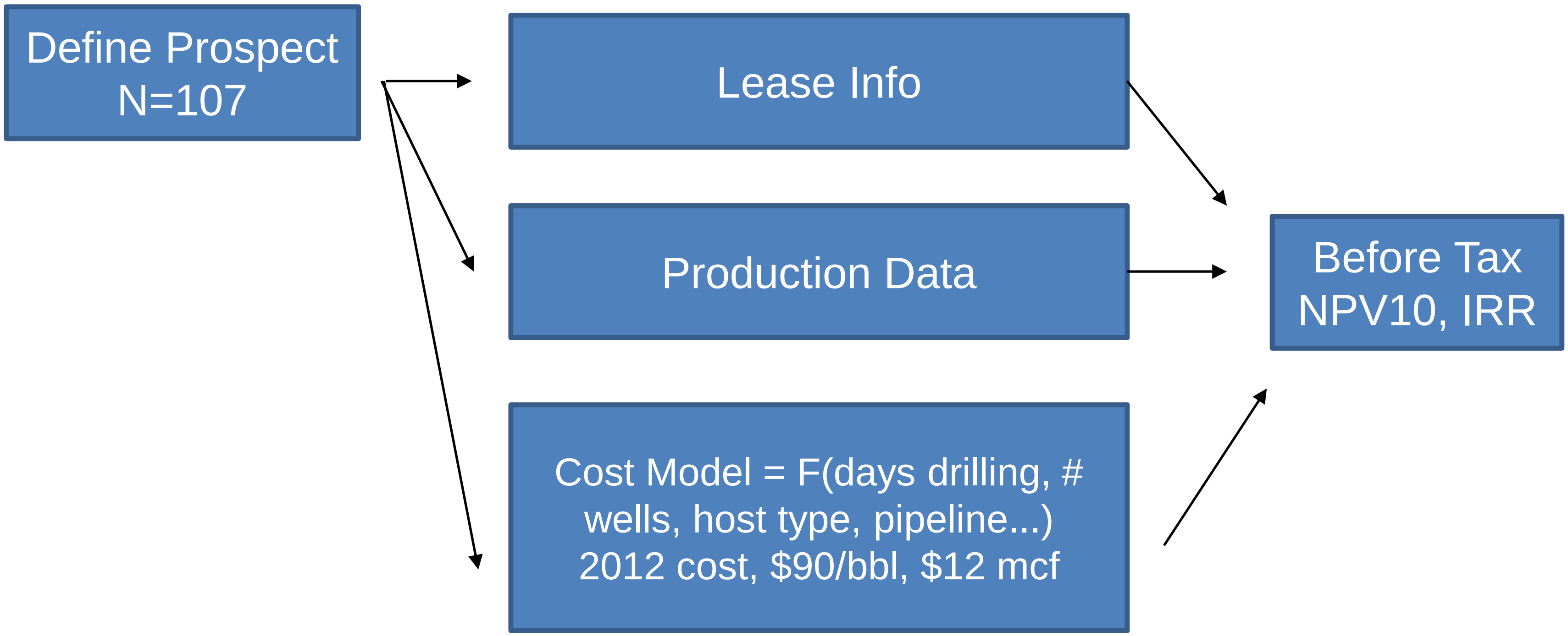


Western Geco Ad c. 1988

Western Atlas International
A Litton/Dresser Company

Methodology: Analysis Designed to Estimate "Intrinsic" Upstream Economics

All projects run on 2012 economics but pre-2008 gas prices.



Judgement calls

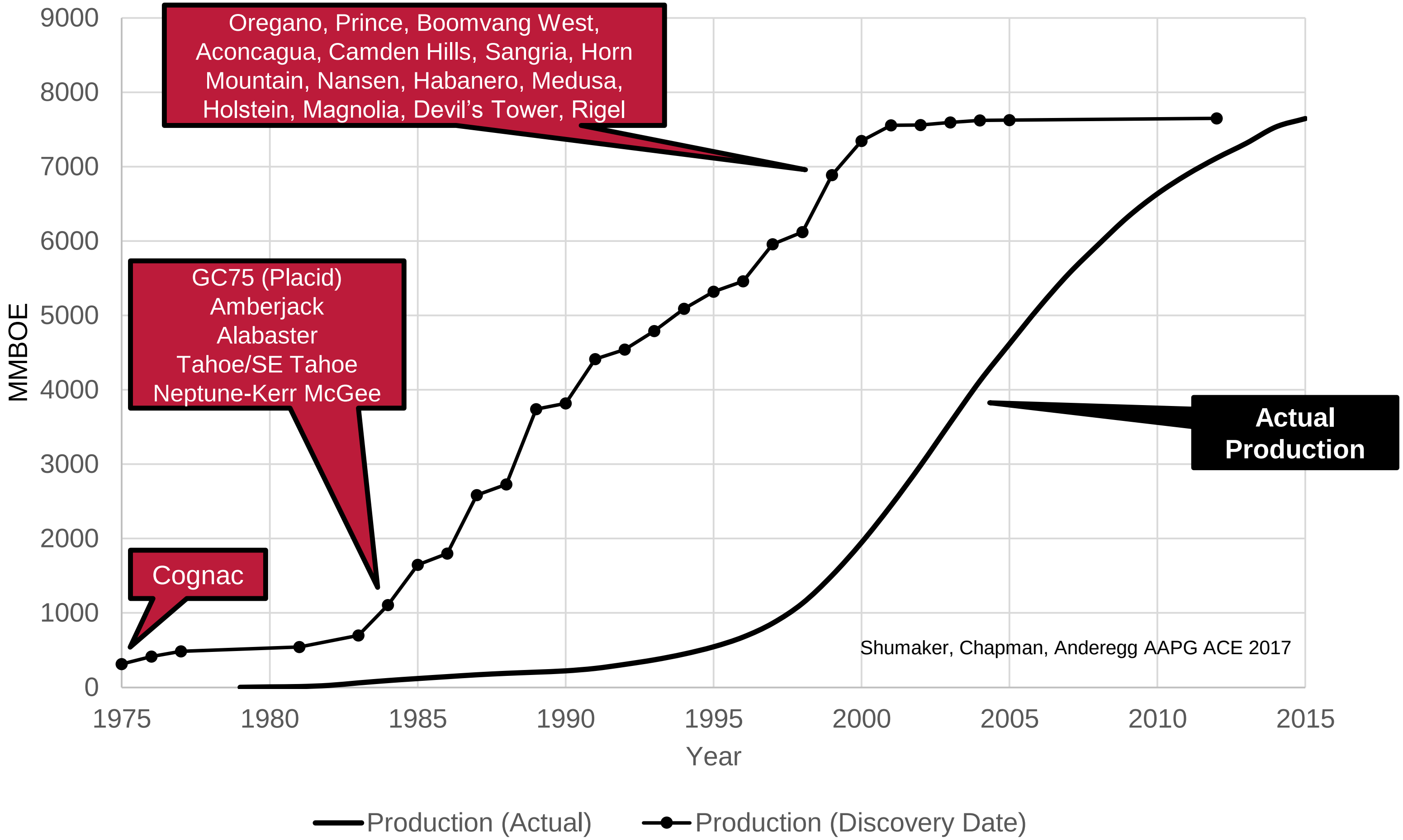
- Lumping or splitting prospects
- Include Cognac?
- Cut-off date?

Assumptions: average costs, no mid-stream

*Data from public sources

Discovery Curve vs. Actual Production

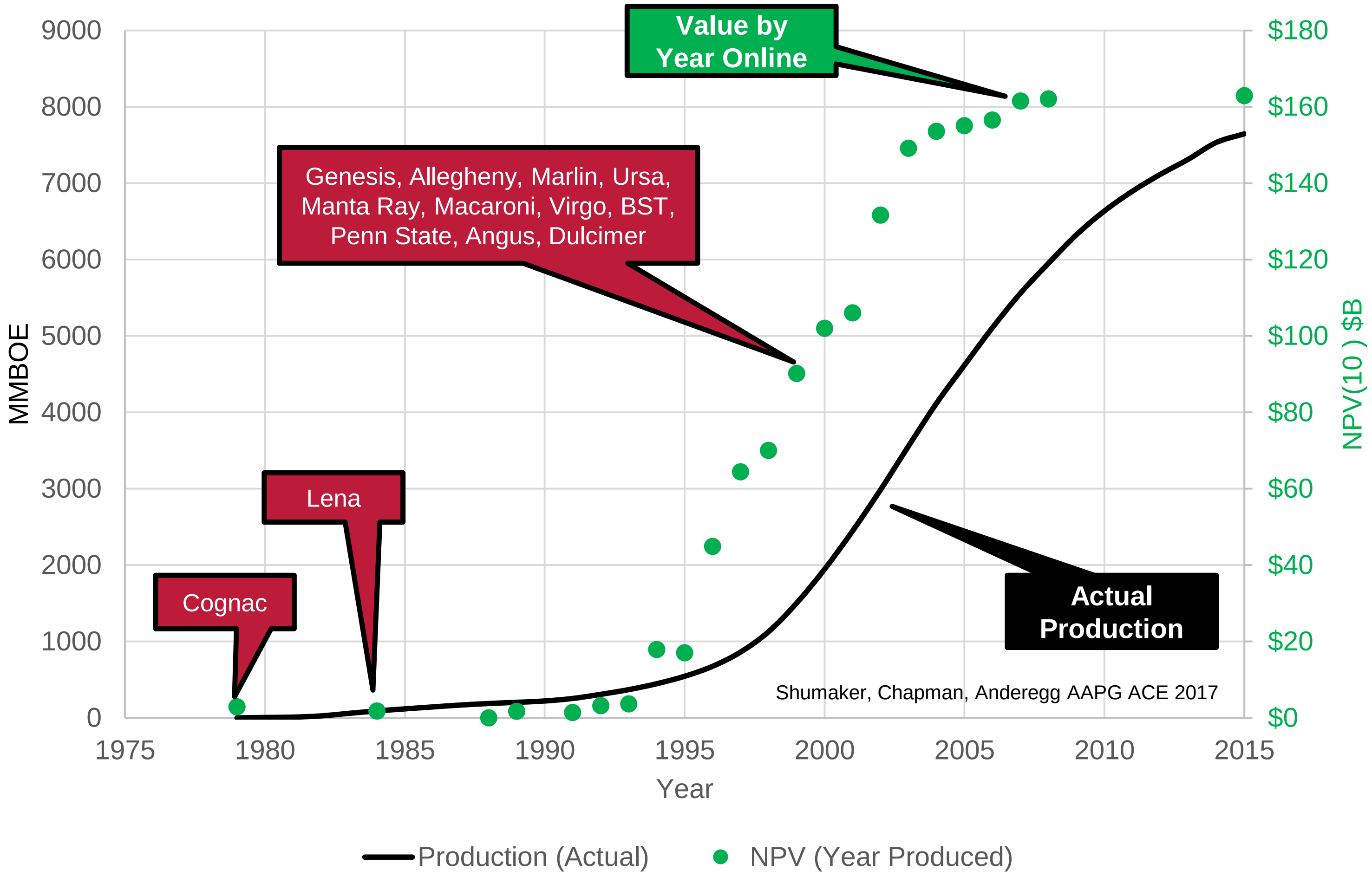
Barrels discovered long before produced



- Smooth production curve due to underlying field performance
- Jagged creaming curve due to lease turnover, technology commoditization
- 10+ year gap between discovery and actual production (~40% discount factor)

Production vs. NPV Curve

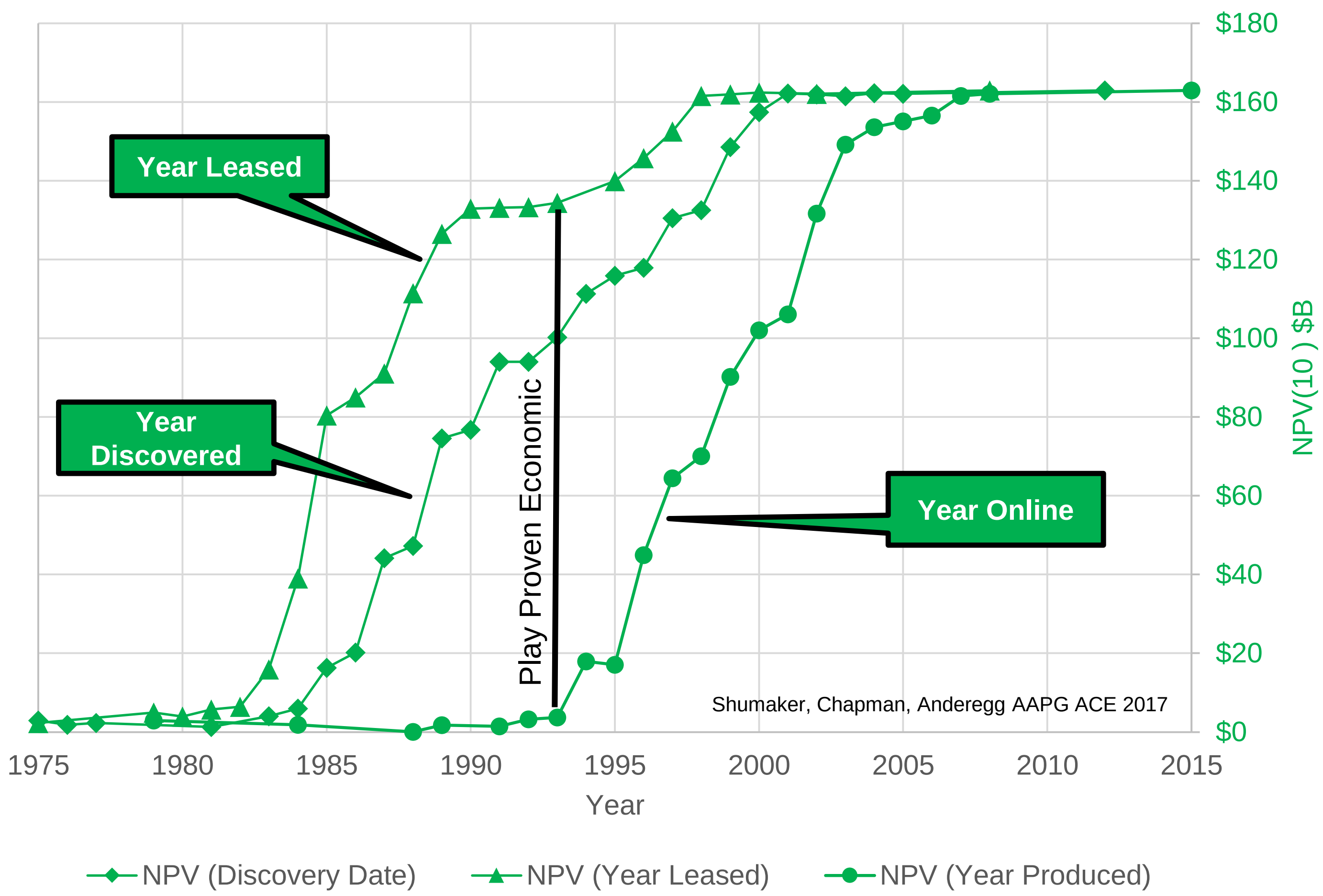
Value not realized until play is established



- $160B in before tax value generated
- Value not generated until play is established
- Most value generated when play is mature

NPV vs. Play Entry Strategy

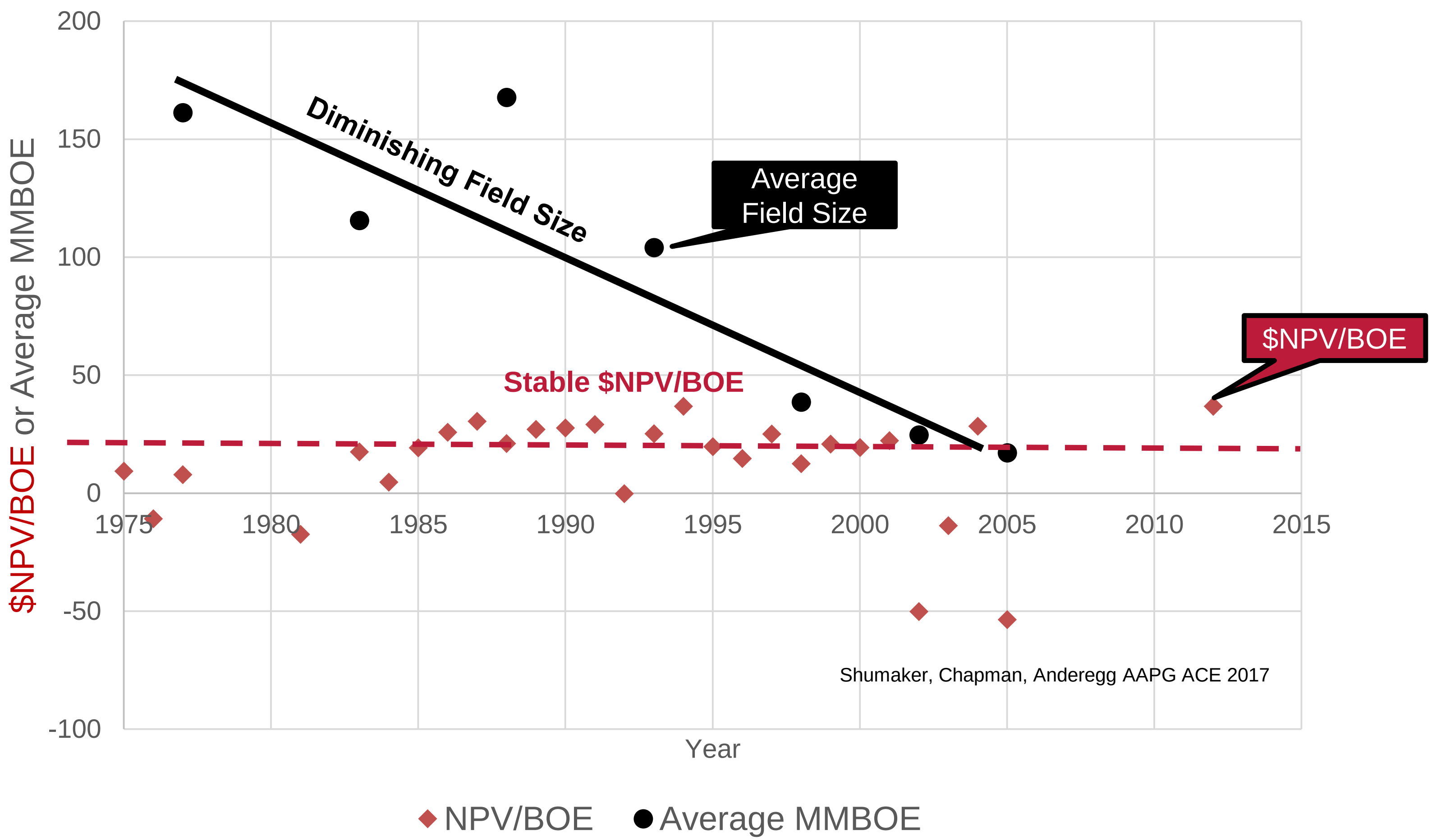
Value generated on early leasehold not first production



- NPV not realized until late in the play
- ~60% of play value discovered before value is proven
- ~80% of play value leased before value is proven

Barrels vs. Value Barrels

Field size diminishes while average value generation/barrel remains stable



- Average field size decreases over time (creaming curve)
- Low value/boe early in play (equipment fails, poor well productivity)
- Then stabilizes (commoditization of technology)
- Marginal hosts tempting late in play cycle

Application to other play types?

Summary

- Entry barrier technologic, not geologic
- All economics run on common terms
- First movers lose
- Early lease hold wins
- Materiality diminishes
- Value/boe remains high throughout play

- ***Subsalt Miocene? (Imaging Barrier)***
- 20k Stack? (Rig, BOP, Tree)
- Wilcox? (Imaging & Rock Quality)

Application to Miocene Subsalt Play in DWGOM

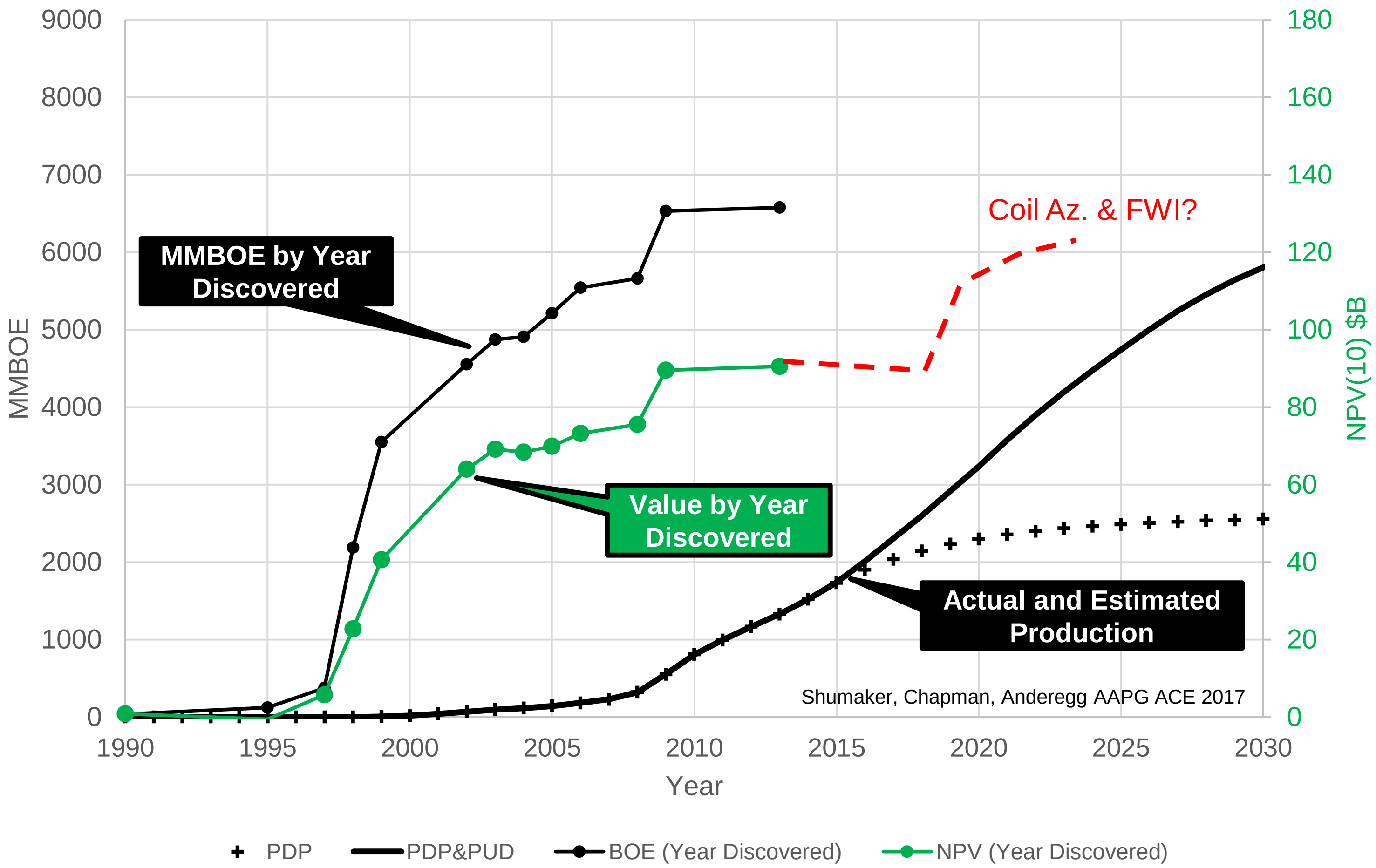
- **22 fields**
  - Centered on MCAVLU depo-system
  - Typically identified on subsalt dip panels or "teaser amplitudes"
- **Play lifecycle 1990-present**
- **Entry barriers**
  - Imaging Technology
  - Difficult wells
  - Capital intensive (appraise by drill-bit)
- **Judgement call on yet to produce**
  - Discount PUD at 15%
  - Estimate on drill days, well recovery etc.
- **Methodology, same cost/price model (2012 dollars)**

Number	Field	Production
1	Gemini	1999
2	Conger	2000
3	Mica	2001
4	K2	2005
5	Mad Dog	2005
6	Lorien	2006
7	Atlantis	2007
8	Neptune-BHP	2008
9	Thunder Horse	2008
10	Thunder Hawk	2009
11	Tahiti	2009
12	Shenzi	2009
13	Caesar-Tonga	2011
14	Tubular Bells	2014
15	Lucius	2015
16	Dantzler	2015
17	Gunflint	2016
18	Kodiak	2016
19	Heidelberg	2016
20	Stampede*	2018
21	Big Foot*	2018
22	Vito*	2021

*Based on in-house and public sources

Value Generation of the Subsalt Miocene Play

Subsalt play has two innovation waves and longer lag between discovery and production

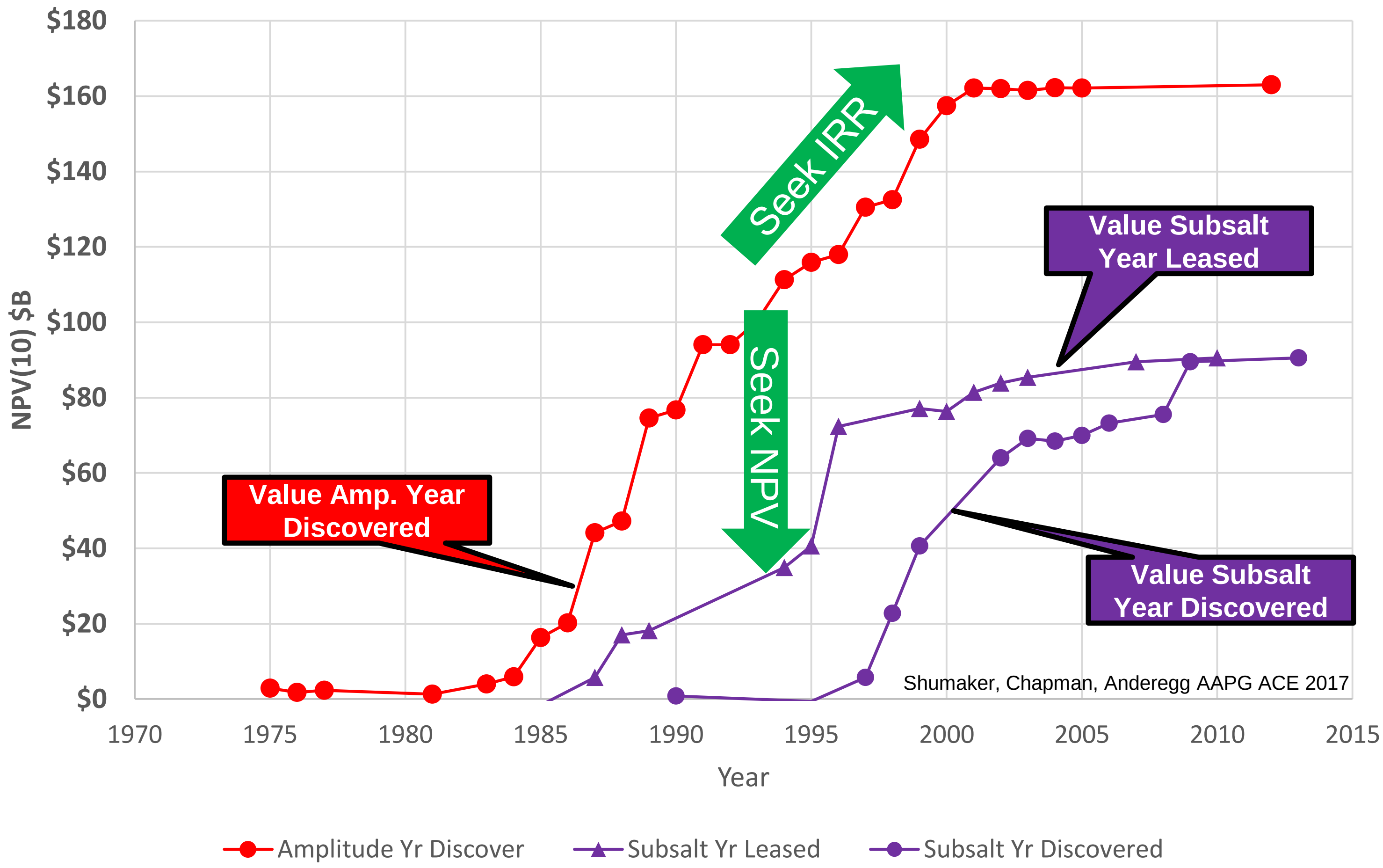


- Same pattern of first mover risk, less value/boe ($14 NPV/boe vs. $21 Amp Play)
- First wave of dip-panel elephants (late 1990's)
- Second wave of wide-az discoveries (2009)
- Third wave: Mulit-az? Coil? FWI? (2020)?

*Post 2015 based on in-house estimates

Right time to move? Transition from Amplitude to Subsalt

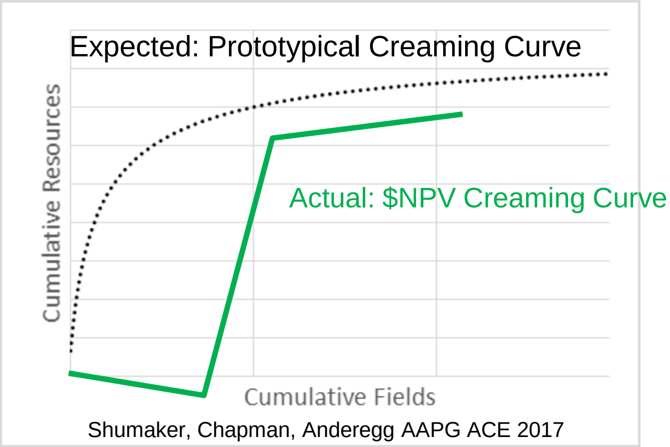
Subsalt value is leased when amplitude play is in its golden age

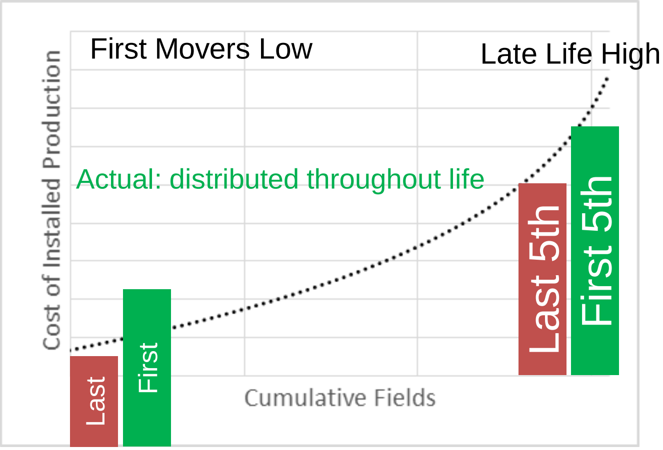


- Importance of alignment with technology strategy (harvest or develop new competencies?)
- Again, benefit of capturing acreage before play tested

Insights: Application to plays hidden behind technology barrier

- **Unexpected Findings**
  - Value Creaming Curve not Parabolic
  - First and last quintiles with lowest and highest cost of marginal production
- **Strategic insights**
  - Limited advantage of testing the play
  - Advantage of being early lease holder
  - Relying too long on established plays
- **Benefits of methodology**
  - Compel integration between engineering, commercial, geoscience, and innovation teams
  - Value vs. resource driven
- **Alignment of technology and exploration strategy**
  - In-house competencies & resources
  - Positioning with service co's & supply chain
- **Special Thanks**
  - Co-authors Tim Chapman and Kevin Anderegg
  - Theme chair for opportunity to present
  - NBL management permission to present





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