Abstract

Hydrocarbons have been commercially produced in Trinidad and Tobago for more than 100 years, the majority of which is extracted from shallow Plio-Pleistocene deltaics both onshore and offshore on the present-day shelf. The discovery of the giant El Furrial Cretaceous shelfal sandstones in Venezuela in the 1980's caught the attention of Exxon, who followed the structural and stratigraphic trend into the more politically stable part of the Eastern Venezuelan Basin, in Trinidad and Tobago. Regional 2D seismic data was acquired, processed and deep tests were done by the drill bit in the 1990's. Consistently, the wells encountered well developed deep water turbidites but with sub-commercial volumes. The conclusion was that the multiple phases of structural deformation in the Trinidad area had severely altered Cretaceous traps, allowing secondary and tertiary migration, and the establishment of many compartments within large anticlinal features. The most southerly of these wells, however, encountered multiple limestone units and gave hints of longstanding unconformities.

Drilling in the Suriname and Guyana area, the offshore Guiana Basin, began in the 1960's with many wells encountering thick shelfal Cretaceous sandstones with some having traces of bypassed hydrocarbon. Many wells, guided by 2D seismic encountered thick Eocene to Cretaceous limestones strongly suggesting a thriving carbonate system on the north eastern Latin American shelf albeit prone to multiple unconformities. Counter clockwise rotation of Africa and South America during the Cretaceous rifting and drifting phase resulted in subtle thick-skinned folding and uplift of the southern rim of this basin, giving rise to the onshore heavily biodegraded Tambarejo oilfield in Suriname, with folded Paleocene fluvial to deltaic sandstones sitting on well cemented Cretaceous turbidites. The conclusion drawn by many a company in the Guiana Basin was the lack of a competent up dip seal, possible remigration due to subtle structural events and no shortage of thief zones in Darcy quality overlying reservoirs, meant that finding a large prospect was unlikely.

Political tensions also brewed between Guyana and Suriname for many years until the maritime boundary was firmly established in 2007. Similarly, the over 100-year-old dispute between Venezuela and Guyana on their shared maritime boundary reached a tipping point in 2015 after Exxon’s Liza-1 discovery well in Guyana’s deep water. This matter has since been referred to the International Court of Justice by the United Nations.
From Deep Horizon to Deep Water

a North Eastern Latin America success story, for some...

Xavier Moonan & Javed Razack
AAPG GTW Beijing
Deep and Ultra-deep Petroleum Systems:
What we know and don’t know
October 2018
Acknowledgements
Outline

• Geological Introduction to NE Latin America
  Trinidad’s Southern and Columbus Basins and the Suriname-Guyana Basin

• The Deep Horizon
  Exploration in Venezuela & Trinidad

• Deepwater Success & Failure..
  Guyana & Suriname

• Guyana 2020 and Beyond:
  Liza Phase 1, Phase 2 and beyond
From Deep Horizon to Deep Water: a North Eastern Latin America Success Story for some, X. Moonan
In NE Latin America
What is Deep Horizon? What is Deepwater?
What We Know & Don’t Know?

• **Deep Horizon** has been primarily considered the deep drilling to test reservoirs within or adjacent to the source rock – Cretaceous/Jurassic. Coined the ‘Cretaceous’ or ‘Transform Margin’ Play. Onshore Eastern Venezuela and Trinidad these plays have been proven to occur from 1500m to 5000m below sea level, and hence have been rarely drilled.

  **Challenges:** Imaging, Seal Integrity, and Reservoir Deliverability.

• **Deepwater Guyana / Suriname / French Guiana / Trinidad / Barbados** – 1800-3000m water depth. Targets are primarily deepwater Cretaceous sandstone turbidites in Guyana, Suriname and French Guiana. In Trinidad and Barbados targets are primarily Late Miocene-Eocene sandstone turbidites.

  **Challenges:** Tuning! Imaging Stratigraphic Traps, Seal Integrity & Migration Pathways.

  **Other Challenges:** - Drilling Technology, Cost and Size to Commercialize.

From Deep Horizon to Deep Water: a North Eastern Latin America Success Story for some, X. Moonan
**Geological Setting** – Central Atlantic Opening, Guyana Transform step over to Yucatan

**Characteristics:**
- Faulting/Extension
- Continuous opening of restricted Central Atlantic
- Dolerite dykes (NE-SW)
- Takutu Graben – continental sediments
- Formation of grabens

From Deep Horizon to Deep Water: a North Eastern Latin America Success Story for some, X. Moonan

Clyde Griffith, 2017
Geological Setting – Opening of Proto Caribbean Seaway, Rotation of Africa

Tectonic Evolution: South Atlantic Rifting

Characteristics:
- Compression in the Equatorial Atlantic
- Takutu Graben – lacustrine sediments
- Inverted structures exposed, local unconformities – Demerara Plateau

From Deep Horizon to Deep Water: a North Eastern Latin America Success Story for some, X. Moonan
Geological Setting – Drift and rapid deepening compounded by High Sea Levels

Tectonic Evolution: Equatorial Atlantic Rifting & Drift Phase

Characteristics:
- Rifting in the Equatorial Atlantic
- Drowning of Inverted structures, rapid deepening
- Open marine settings

From Deep Horizon to Deep Water: a North Eastern Latin America Success Story for some, X. Moonan
Geological Setting

- Established passive margin at Guyana, Surinam
- Active margin tectonics in the Trinidad area due to the apparent eastward advancement of the Caribbean Plate

Offshore: Satellite Derived, v24.1

Onshore: Earth Gravity Model 2008


- Well established transforms which link the area to hydrocarbon discoveries on the west coast of Africa.
- Note the distinct change from Continental Crust to attenuated Continental Crust and Ocean Crust
- Inherent structural grain

Mark Longacre, 2017
Deep Horizon Exploration in Venezuela & Trinidad

*In search of the El Furrial .....& equivalent*

Early-Mid Proterozoic (1.9-1.5Ga) Roraima Group sandstone tepuis
Angel Falls, Venezuela

Turonian-Campanian Cretaceous Naparima Hill argillite
San Fernando Hill, Trinidad
Pointe-a-Pierre Refinery in foreground
1978 Lagoven, S.A., an affiliate of Petroleos de Venezuela, S.A., commenced an exploration program aimed at deeper targets on the northern flank of the Eastern Venezuelan basin. Here the shallow upper Tertiary section had been explored for more than eight decades.

Quality of the seismic data acquired was sufficiently able to give indications of thrust faults with associated structures. By 1985 sufficient geologic surveying delineated the first prospect: El Furrial.

Spud in 1986, the FUL-1 discovery well, penetrated 276 m (905 ft) net oil sand, with porosities ranging from 11 to 16% within the Late Oligocene Naricual Formation and produced up to 7331 bbl of 26° API oil per day.

Field delineated as approximately 12km long and 7km wide. Estimated OOIP was 6BBO. Became the largest single discovery of medium-gravity oil in the last 25 years in South America.

The El Furrial discovery represents an excellent example of the prospectivity of a foreland overthrust area and also an example of continued successful exploration to pursue deeper objectives in an area already considered mature.
Trinidad – ‘the graveyard of geologists’

- First oilwell drilled by the American Merrimac Company in 1857 at a depth of 280ft but was not commercially viable.
- Some 13000 wells have been drilled, producing just over 3.5BBO and 12TCF Gas, primarily from Pleistocene to Late Miocene deltaic sandstones.
The imaging challenge – Onshore Southern Basin Consortium 2D Seismic Line TD91-177

From Deep Horizon to Deep Water: a North Eastern Latin America Success Story for some, X. Moonan
In 1989 Exxon, Total, Chevron, Trintoc and Trintopec come together to form the Southern Basin Consortium to explore the southern part of Trinidad for structures similar to El Furrial.

Three wells were drilled onshore – St. Croix-1, Rocky Palace-1 and Iguana River-1. All wells tested Cretaceous fold structures.

The wells penetrated Cretaceous sandstones, modeled by Exxon to be deep water turbidites, encased in shales.

All sandstones demonstrated residual oils or sub-commercial accumulations.

The St. Croix-1 well encountered Cretaceous shales that were mature. The shales at Rocky Palace-1 and Iguana River-1 were shown to be thermally immature as a potential source rock.

Leon Aden and Robert Bierley Exxon Exploration Company Houston USA; Structural Development of the Southern Basin, Onshore Trinidad: Implications for Hydrocarbon Entrapment

Trinidad – ‘the graveyard of geologists’

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Southern Basin Consortium

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propagation folds that involved Cuche Formation. Two sandstone intervals were penetrated (9950'-10050' and 11408'-11512'). Trap leakage due to steeply dipping folds. The thrust penetrated at 11745' MD place the Gautier beneath the Cuche. The reoccurrence of Cuche sands in the footwall (12630'-12762' MD) contain bitumen and probable water."

From Petrophysics

"From 9950'-9970' is normally considered indicative of hydrocarbon saturation but this same pattern is observed in the overlying shale and maybe a result of borehole damage. Four feet of core, all tight, were recovered in the interval. The core data was aligned to the wireline logs using the MWD logs. The maximum core porosity measured was 6.75pu. Measured grain densities ranged from 2.733 to 2.748 g/cc. The cores were described as limey. The high grain densities indicate a heavy carbonate cement rather than just calcite. There were no indications of hydrocarbons in the cores."

Iguana River-1 Exploration Well & Salt Spring

Spud: April 1st 1993
Drilling Completed: August 24th 1994
Drilling Rig: Helmerich and Payne 117
Drilling Days: 169.7
Cost: 13,150,000 USD

From Deep Horizon to Deep Water: a North Eastern Latin America Success Story for some, X. Moonan
• Prior to SBC wells, most Cretaceous wells encountered shale with rare fracked shale oil and gas.

• Exxon and partners proved that large deep water sand rich turbidite fans exist with possible shelfal limestones.

• One such ‘goldilocks area’ falls within the ‘crush zone’ in Trinidad.

• Seismic data was used primarily to identify structural traps.

• Though large structures were imaged, when tested these anticlines appear to have undergone multiple stages of folding and extension due to the ever changing dominant stress regime, resulting in breached seals.

• In 1996 Exxon relinquished their blocks and exited Trinidad and Tobago.
Early Exploration in Guyana & Suriname

Early-Mid Proterozoic (1.9-1.5Ga) Roraima Group sandstone tepuis
Kaieteur Falls, Guyana

Mid Proterozoic (2.1-1.9Ga) Armina Fm metasedimentary greenschist inselbergs
Voltzberg, Suriname

From Deep Horizon to Deep Water: a North Eastern Latin America Success Story for some, X. Moonan
Guiana Basin

- In 1996 Exxon relinquished their blocks and exited Trinidad and Tobago. In 1997 Exxon acquired the Stabroek Block, offshore Guyana.
- The Guyana Basin (120,000 sq km) is part of the larger Guiana Basin, and is bounded by Demerara Plateau to the South, Pomeroon Arch to the North, coastal Guyana and extends approx. 400km offshore. Pomeroon Arch is the structural high separating Eastern Venezuelan Basin and Guiana Basin.
- The United States Geological Survey (USGS) ranks the Guiana Basin 2nd in the world for prospectivity among the world’s unexplored basins and 12th for oil among all the world’s basins – explored and unexplored. The mean (P50) undiscovered resource potential is estimated at 15.2 billion bbls (World Petroleum Assessment, 2000.)

From Deep Horizon to Deep Water: a North Eastern Latin America Success Story for some, X. Moonan
Guyana /Suriname Stratigraphy

- During the break-up commencing in the Jurassic and progressing through the Cretaceous, Africa and South America drifted along transform fault boundaries resulting in the evolution of the Guyana-Suriname basin.

- Initially, there was a thick deposition of Jurassic to Early Cretaceous sediments.

- Subsequently, a thick succession of Late Cretaceous to Recent sedimentary rock in depositional environments ranging from near coastal to deep-marine in which there were intervals of carbonates.

- It is generally referred to as a passive margin basin.
Guiana Basin evolved on heavily attenuated / stretched Pre-Cambrian Continental Crust and Jurassic Oceanic Crust primarily due to the northwestward step over along the Guyana Transform Fault resulting in the zig-zag opening and formation of the Proto-Caribbean seaway.

Decreased differential stretching from E-W together with the associated NW-SE trending transfer faults resulted in a serrated northern margin of South America due to changes from normal to attenuated continental crust from south to north, with an east facing cascading effect along the northern margin of South America. As such, Trinidad and Guyana in particular were placed in a more basinward position/deepwater setting when compared to the rest of the Present Day north eastern margin of South America.
# Offshore Guyana Drilling History

<table>
<thead>
<tr>
<th>Year</th>
<th>Well</th>
<th>Operator</th>
<th>TD (ft)</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1967</td>
<td>Guyana Offshore-1</td>
<td>Tenneco</td>
<td>8930ft</td>
<td>Gas shows</td>
</tr>
<tr>
<td>1967</td>
<td>Guyana Offshore-2</td>
<td>Tenneco</td>
<td>7600ft</td>
<td>Minor Gas Shows</td>
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<tr>
<td>1971</td>
<td>Berbice-1</td>
<td>Shell</td>
<td>12,500ft</td>
<td>Oil Shows</td>
</tr>
<tr>
<td>1971</td>
<td>Berbice-2</td>
<td>Shell</td>
<td>10,000ft</td>
<td>Gas Shows</td>
</tr>
<tr>
<td>1974</td>
<td>Mahaica-1</td>
<td>Shell</td>
<td>8,000ft</td>
<td>No shows</td>
</tr>
<tr>
<td>1974</td>
<td>Essequibo-1</td>
<td>Deminex</td>
<td>11,200ft</td>
<td>Oil Shows</td>
</tr>
<tr>
<td>1975</td>
<td>Abary-1</td>
<td>Shell</td>
<td>13,000ft</td>
<td>37 API oil flowed</td>
</tr>
<tr>
<td>1976</td>
<td>Mahaica-2</td>
<td>Shell</td>
<td>7,500ft</td>
<td>No Shows</td>
</tr>
<tr>
<td>1977</td>
<td>Essequibo-2</td>
<td>Deminex</td>
<td>13,000ft</td>
<td>Oil and gas Shows</td>
</tr>
<tr>
<td>1992</td>
<td>Arapaima-1</td>
<td>Total</td>
<td>11,090ft</td>
<td>Minor Gas Shows</td>
</tr>
<tr>
<td>2000</td>
<td>Horseshoe-1</td>
<td>CGX</td>
<td>12,750ft</td>
<td>No Shows</td>
</tr>
<tr>
<td>2012</td>
<td>Eagle-1</td>
<td>CGX</td>
<td>13,500ft</td>
<td>Oil and Gas Shows</td>
</tr>
<tr>
<td>2012</td>
<td>Jaguar-1</td>
<td>Repsol</td>
<td>15,600ft</td>
<td>Light Oil recovered, HPHT Well</td>
</tr>
<tr>
<td>2015</td>
<td>Liza-1</td>
<td>ExxonMobil</td>
<td>17,825ft</td>
<td>Major Oil Discovery</td>
</tr>
</tbody>
</table>

Sources: various published reports

NB. 1st onshore well in 1916

From Deep Horizon to Deep Water: a North Eastern Latin America Success Story for some, X. Moonan
Guyana Shelf to Deepwater success/failures

1967, Conoco/Tenneco drilled GO #1 well which encountered gas shows. The second, GO #2, had minor gas shows. Shelf sands target.

1971, Shell/Conoco drilled Berbice#1 which was abandoned due to drilling problems after a gas kick at 7,124 ft. Berbice#2 was drilled, finding only minor gas shows and oil stains.

1974, Shell drilled Mahaica#1, abandoned dry. Turbidite sands and limestone targets.

1974, Deminex drilled Essequibo #1 which had several oil shows

1975 Abary#1 was drilled in the deepest part of Shell’s OPL in the offshore basin. It kicked violently at 13,091 ft. Turbidite target.

1976, Shell drilled Mahaica#2, also abandoned dry. Turbidite sands and limestone targets.

1977, Deminex drilled Essequibo #2, oil and minor gas shows. Turbidite sands and limestone targets

1991, TOTAL/PETREL/GEL drilled the Arapaima-1 offshore well. Limestone and sands target

2000, CGX rig was driven off the Eagle site by Suriname warships. Horseshow was spud instead. 2012 Eagle was spud.
Fun Fact: 🌋 was originally partnered with Exxon in the Stabroek Block but pulled out around 2012. This forced Exxon and the government to seek out other partners, paving the way for Hess and Nexen.
Operators
- CGX
- Anadarko
- Exxon
- Tullow
- Repsol

Roraima: 100% Anadarko

Kaieteur:
- 35% Exxon
- 15% Hess
- 25% Ratio Oil
- 25% Catalaya Energy Ltd

Stabroek:
- 45% Exxon
- 30% Hess
- 25% Nexen

Canje:
- 35% Exxon
- 35% Total
- 30% Mid Atlantic Oil and Gas + JHI Associates Inc

Demerara: 100% CGX

Orinduiik:
- 60% Tullow
- 25% Total*
- 15% Eco Oil and Gas Ltd

Kanuku:
- 37.5% Repsol
- 37.5% Tullow
- 25% Total

Corentyne: 100% CGX

Source: adapted from Apache

Last Updated April 2, 2018
By Javed Razack
Block 59: 33.3% Exxon, 33.3% Hess, 33.3% Equinor

Block 42: 33.3% Kosmos, 33.3% Hess, 33.3% Chevron

Block 48: 100% Petronas

Block 47: 80% Tullow, 20% Ratio Oil

Block 54: 45% Kosmos, 25% Cepsa, 30% Petronas

Block 52: 45% Apache, 25% Cepsa, 30% Petronas, 100% Staatsolie

Blocks A, B, C, D: 100% Staatsolie

Block 60: 100% Equinor

Block 58: 30% Tullow, 50% Equinor, 20% Noble

Block 53: 30% Petronas, 45% Apache, 20% Noble

Block 52: 100% Petronas

Block 47: 3200km²

Block 48: 4750km²

Block 59: 11500km²

Block 54: 8500km²

Block 53: 5000km²

Block 42: 6500km²

Block 61: 13000km²

Blocks A, B, C, D: 11250km²

From Deep Horizon to Deep Water: a North-Eastern-Latin America Success Story for some, X. Moonan
Suriname Recent Shelf to Deepwater success/failures

- **Dry**: 
  - 2008, Noble Energy drilled West Tapir-1 in Block 52 – dry hole
  - 2011, Murphy Oil drilled Aracari-1 and Caracara-1 near Block 61 – dry hole
  - 2011, Inpex drilled Aitkanti-1 near Block 58 – dry hole
  - 2015, Inpex drilled Spari-1 in Block 31 – dry hole
  - 2015, Apache drilled Popokai-1 in Block 53 – dry hole
  - 2016, Petronas drilled Roselle-1 in Block 52 – dry hole
  - 2017, Apache drilled Kolibrie-1 in Block 53 – dry hole
  - 2018, Kosmos drilled Anapai-1 and Anapai-1A in Block 45 – dry hole.
  - 2018 Kosmos drilled Pontoenoe-1 in Block 42 – dry hole.

- **Gas Shows**: 
  - 2008, Noble Energy drilled West Tapir-1 in Block 52
  - 2018 Kosmos drilled Pontoenoe-1 in Block 42

- **Oil & Gas Shows**: 
  - 2008, Noble Energy drilled West Tapir-1 in Block 52
  - 2018 Kosmos drilled Pontoenoe-1 in Block 42

- **Oil Discovery**: 
  - 2011, Murphy Oil drilled Aracari-1 and Caracara-1 near Block 61
  - 2015, Apache drilled Popokai-1 in Block 53
  - 2016, Petronas drilled Roselle-1 in Block 52
  - 2017, Apache drilled Kolibrie-1 in Block 53
  - 2017, Tullow drilled Araku-1 in Block 54 (2017)
  - 2018, Kosmos drilled Anapai-1 and Anapai-1A in Block 45
  - 2018 Kosmos drilled Pontoenoe-1 in Block 42

From Deep Horizon to Deep Water: a North Eastern Latin America Success Story for some, X. Moonan
Suriname – What’s Next?

- oil shows
- gas shows
- oil & gas shows
- oil discovery

Tullow to drill in Block 47. 2019? 2020?

Petronas and Equinor conducted 3D seismic in 2017/2018 in blocks 48 and 60. Drilling to occur in late 2019 or 2020?

Cairn signed Block 61 in 2018. 2D seismic to occur in 2019.

Staatsolie to drill at least 10 nearshore wells in Blocks A, B, C, D in 2019 to 2020.

Exxon to conduct 3D seismic in Block 59. Late 2018? 2019?

Apache to drill in Block 58 in 2019.
Recap - Petroleum System

• **Source** - Cenomanian to Turonian aged Canje Formation (U. Cretaceous). Equivalent of Naparima Hill (Trinidad), La Luna (Venezuela), Saramacca (Suriname). ~500m thick, Type II Marine, TOC 4 – 7%. Possible Jurassic aged Source Rock in parts.

• **Traps** – stratigraphic (turbidites pinching out, shale top seal, show up as bright amplitudes). NB. Only 15% of exploration wells in last 10 years globally have targeted stratigraphic traps (Zanella, 2017)

• **Reservoirs** - main reservoir targets are Upper Cretaceous and Lower Tertiary basin floor fans, shelf-margin deposits and turbidites directly overlying the source rock. Mainly sandstone reservoirs (New Amsterdam and Georgetown Fm) but now carbonate reservoirs of commercial volumes have been discovered (Ranger-1)

• **Seals** – deep marine shales at multiple levels

• **Migration Pathways** – along stratigraphy; by fracturing of reservoir rock above source; along faults.

• **Timing** – migration must occur after reservoir, trap and seal are in place.
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Recent 3D Seismic surveys in Guyana
- *image it and image it better*

- CGX - Corentyne (PGS 2012 3D) – 1160 sq km
- Exxon – Stabroek (CGG 2013 3D) – 17,000 sq km*
- Exxon – Canje (Polarcus 2016 3D) – 7760 sq km
- Exxon – Stabroek (PGS 2017 4D) – 2200 sq km
- Exxon – Kaieteur (Polarcus 2017 3D) – 5700 sq km
- Repsol – Kanuku (WesternGeco 2017 3D) – 4000 sq km
- Tullow – Orinduik (WesternGeco 2017 3D) – 2500 sq km

*Anadarko – In 2013, MV Teknik Perdana was conducting a geotechnical survey in the Roraima Block and was impounded by the Venezuelan Navy. The crew of 36 was detained and later released. Anadarko had a 2D survey planned later in 2013. No activity since. Border dispute referred to UN.

Source: adapted from Apache
From Deep Horizon to Deep Water: a North Eastern Latin America Success Story for some, X. Moonan
From Deep Horizon to Deep Water: a North Eastern Latin America Success Story for some, X. Moonan

http://investors.kosmosenergy.com
From Deep Horizon to Deep Water: a North Eastern Latin America Success Story for some, X. Moonan
This is a model for the famed Liza discovery in 2015. A Cretaceous stratigraphic trap formed by turbidite sandstones with over 1 billion barrels in offshore Guyana. Migration of hydrocarbons mostly follows stratigraphic bedding due to vertical capillary contrasts. Lateral fault seals, pinch out or structure closures led to vertical migration and charging of the shallower reservoirs. Potential pay zones remain in the deeper section.

Canje Formation

From Deep Horizon to Deep Water: a North Eastern Latin America Success Story for some, X. Moonan
Guyana 2020 and Beyond

Source: Hess media release 2018

Currently 2 drillships operating for Exxon – Nobel Bob Douglas and Stena Carron

From Deep Horizon to Deep Water: a North Eastern Latin America Success Story for some, X. Moonan
Liza Phase 1 & 2

Lisa Phase 1
• FPSO, 120 KBD
• 17 wells
• 8 producers, 3 gas injectors, 6 water injectors

Production Start-up in March 2020

Lisa Phase 2
• FPSO, 220 KBD
• ~35 wells from 2 drill centres
• 19 producers, 6 gas injectors, 15 water injectors
• 2nd FPSO ordered from SBM

Anticipate Production Start-up in Q2 2022

From Deep Horizon to Deep Water: a North Eastern Latin America Success Story for some, X. Moonan
Including all discoveries, Guyana oil production could exceed 700 kbbl/d by 2030

Expected crude oil production from Guyana by field
Thousand barrels per day

Source: Rystad Energy/UCube

J. Razack, Sep 2018
Upcoming / Ongoing Activities

• Stena Carron to continue with exploration/appraisal drilling.
• At least 25 prospects identified in Stabroek.
• Bob Douglas to continue with 17 Liza Phase 1 development wells.
• 3rd Noble Rig to arrive in Q4 2018 for additional exploration (Tom Madden).
• 4th rig during 2019. 5th rig rumored.
• Exploration Drilling to occur in Kaieteur and Canje Blocks by Exxon
• Exploration Drilling from Repsol, Tullow and CGX in 2019 / 2020.
• Potential gas pipeline and 200MW power plant to be built onshore.
• Possible start of downstream industry
Summary

• Integrating modern seismic with well data and structural models brought light to Deep Horizon potential.

• Liza is Exxon’s largest current deepwater development. 1st 4D seismic in region being done by Exxon to better efficiently produce. Production peak will be at least 700k bopd by 2030.

• Drilling by other operators in Guyana to come in 2019/2020.

• Suriname side yet to have major discovery offshore – will change soon!

• From Deep Horizon to Deepwater, the game hasn’t changed much, the demand however is higher due to greater commercial risks: find a large undisturbed deepwater turbidite, image its updip trap and tie it back to its provenance, ensure it isn't being cannabalized by younger turbidites and that its porosity isn't being occluded by the shelfal carbonate influx.

• Unless you have a subsurface team willing to think ‘outside of the box’, you will likely continue to fail.
Thank you!
Questions?
Fact: Liza Phase 1 is expected to break even at US 35 / bbl!!

<table>
<thead>
<tr>
<th></th>
<th>Guyana Liza Phase 1 Development¹</th>
<th>Delaware Basin Illustrative 50,000 Net Acre Development²</th>
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</thead>
<tbody>
<tr>
<td>Peak Production</td>
<td>120,000 BOED</td>
<td>120,000 BOED</td>
</tr>
<tr>
<td>Peak Production Oil</td>
<td>120,000 BOD</td>
<td>86,000 BOD</td>
</tr>
<tr>
<td>Initial Investment to Peak Production</td>
<td>3 years</td>
<td>10+ years</td>
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<tr>
<td>Reservoir Quality</td>
<td>Multi Darcy</td>
<td>Micro Darcy</td>
</tr>
<tr>
<td>Total Production Wells</td>
<td>8</td>
<td>1,400</td>
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<tr>
<td>Avg. EUR / Production Well</td>
<td>56 MMBO</td>
<td>0.9 MMBOE, 0.6 MMBO</td>
</tr>
<tr>
<td>Development Capex</td>
<td>$3.2 Billion</td>
<td>$10.5 Billion</td>
</tr>
<tr>
<td>Unit Development Costs</td>
<td>~$7/BO</td>
<td>~$9/BOE, ~$12.5/BOE</td>
</tr>
<tr>
<td>Cost Environment</td>
<td>Deflating</td>
<td>Inflating</td>
</tr>
<tr>
<td>Required WTI price for 10% Cost of Supply</td>
<td>~$35/bbl</td>
<td>~$45/bbl</td>
</tr>
</tbody>
</table>
Liza Destiny FPSO

- **Liza FPSO:**
  - Oil: 126,000 bbls/day
  - Gas: 189 MMscf/day, gas inj. And/or export
  - Gas Injection: 168 MMscfd @ 579 bar
  - Water Injection: 200 kbwpd @ 448 bar

- **Donor Tanker: Tina**
  - Build: 1999
  - Shipyard: HHI
  - Double Hull

- **Overall Dimensions:**
  - Lpp: 320.00 m
  - B: 58.00 m
  - Depth @ side: 31.00 m
  - Draught: 22.70 m

- **Net Weight**
  - Topsides: 12,863 t

- **Design Life:**
  - 20 years
Beyond

• Liza Phase 1 – 120,000 bopd from FPSO #1 – March 2020
• Liza Phase 2 – 220,000 bopd from FPSO #2 – mid 2022
• Payara and Pacora – 180,000 bopd from FPSO #3 – late 2023
• FPSO #4 for Ranger?
• FPSO #5 for Longtail and Turbot?

NB. #4 and 5 are subject to new exploration and appraisal results.

• With these 8 fields, production may be >700,000 bopd by 2030.
• CAPEX of USD 15 billion to develop 8 fields
• Up to 100 wells to be drilled for these fields
• Carbonate play to be fleshed out. Significant upside potential here.