

Multilateral Stimulation Technology

Force 11th June 2019



MORNING SESSION

AGENDA

- Company
- Technology
- Track record, applications and case histories (JCR)
- How we work
- New technology developments



COMPANY

Fishbones at a glance

Offices

Stavanger, Dubai, Muscat

Employees

25 and growing (11 hires planned for 2019)

Certifications

ISO 9001-2015

Number of SPE papers

7, 1 pending

Awards

ONS Innovation award (2014), OTC Spotlight on new technology (2015), Gullkronen (2016)

First Fishbones Jetting installation

November 2013

First Fishbones Drilling installation

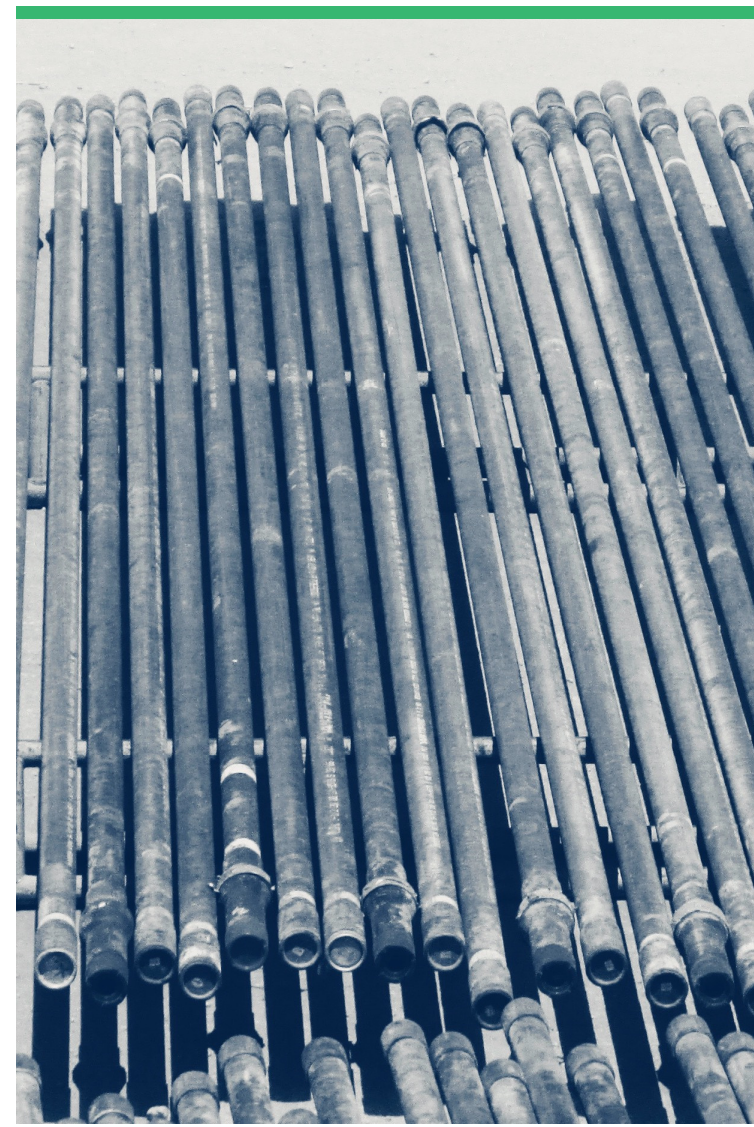
July 2015

Number of installations in 2018

10

Target

>100 installations in 2021



OUR VISION

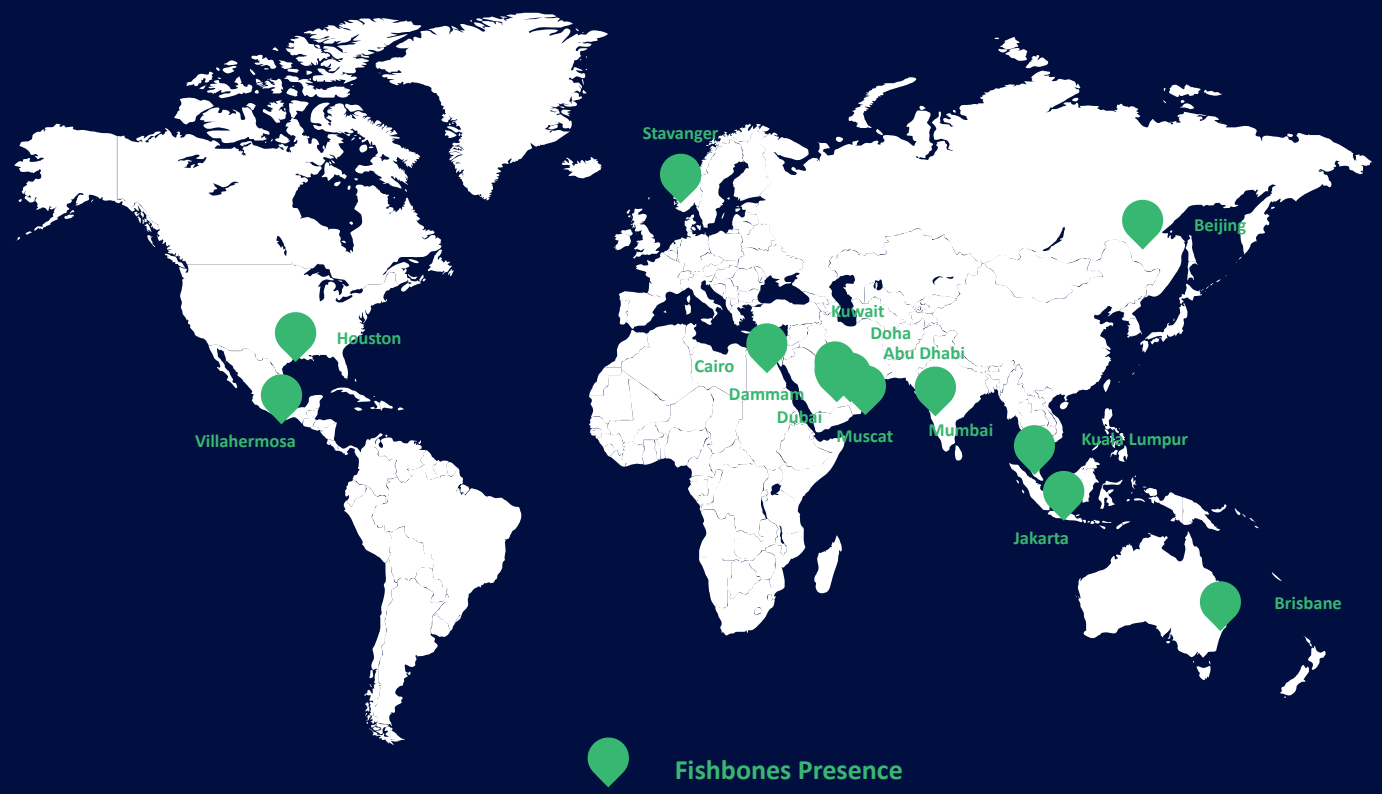
To be the first consideration
For stimulation of conventional reservoirs
worldwide

COMPANY

Global Footprint



- Equinor
- Aker BP
- Total
- Lundin Petroleum
- OXY
- Shell
- ADNOC
- Saudi Aramco
- Kuwait Oil Company
- Badr Petroleum Co
- Tatweer Petroleum
- PetroChina
- Petroleum Development Oman
- Pemex
- CNOOC
- ENI
- California Resources Corporation



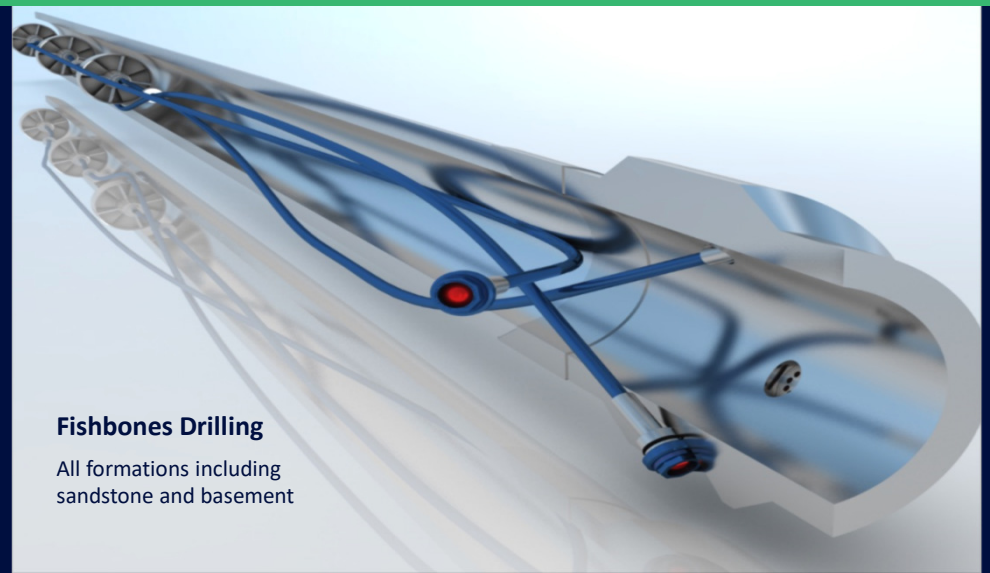
TECHNOLOGY

Product Portfolio



Fishbones Jetting

Carbonates
Coal bed methane
Oil sands



Fishbones Drilling

All formations including
sandstone and basement

Complimentary Fishbones Products:



Backbone Anchor



Fishbones Shoes



Fishbasket

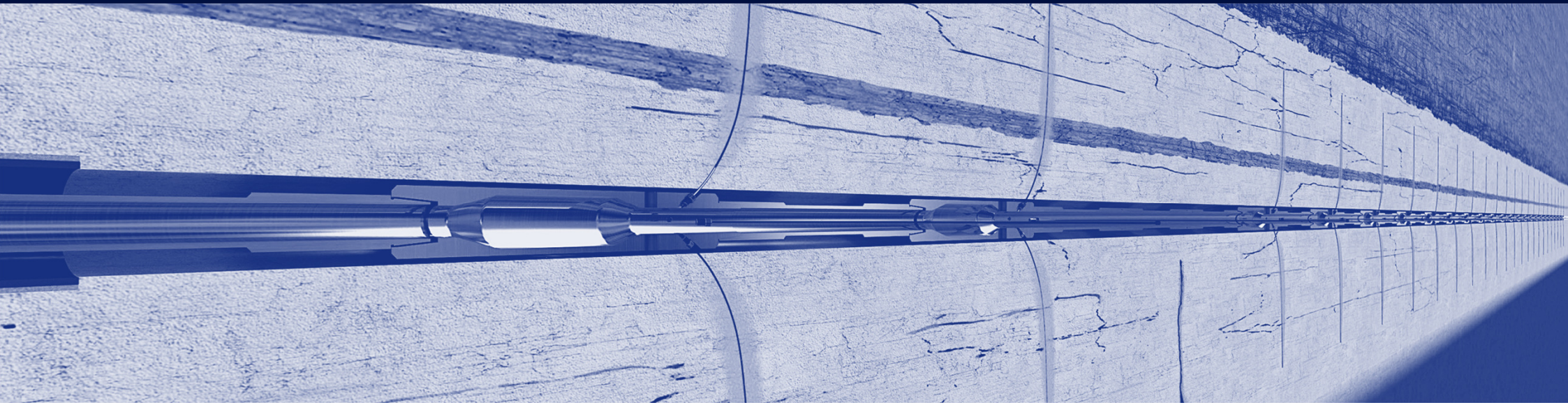


TECHNOLOGY

The value of Fishbones stimulation technology

- ✓ Increase reservoir exposure
- ✓ Connect layered reservoirs
- ✓ Bypass permeability barriers
- ✓ Connect to natural fractures
- ✓ Connect with sweet spots and lenses

- ✓ Accurately stimulate zones
- ✓ Bypass damaged zone
- ✓ Reduce drawdown and reduce coning effects
- ✓ Improve distribution
- ✓ Reduce HSE exposure



TECHNOLOGY

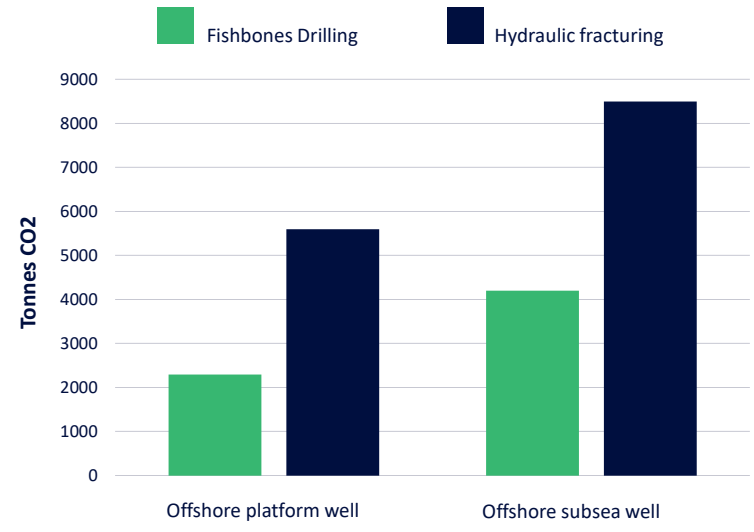
Reduced environmental impact

✓ Accurate stimulation

✓ Reduced CO2 emissions

3rd party study (Add Novatech AS 2016)

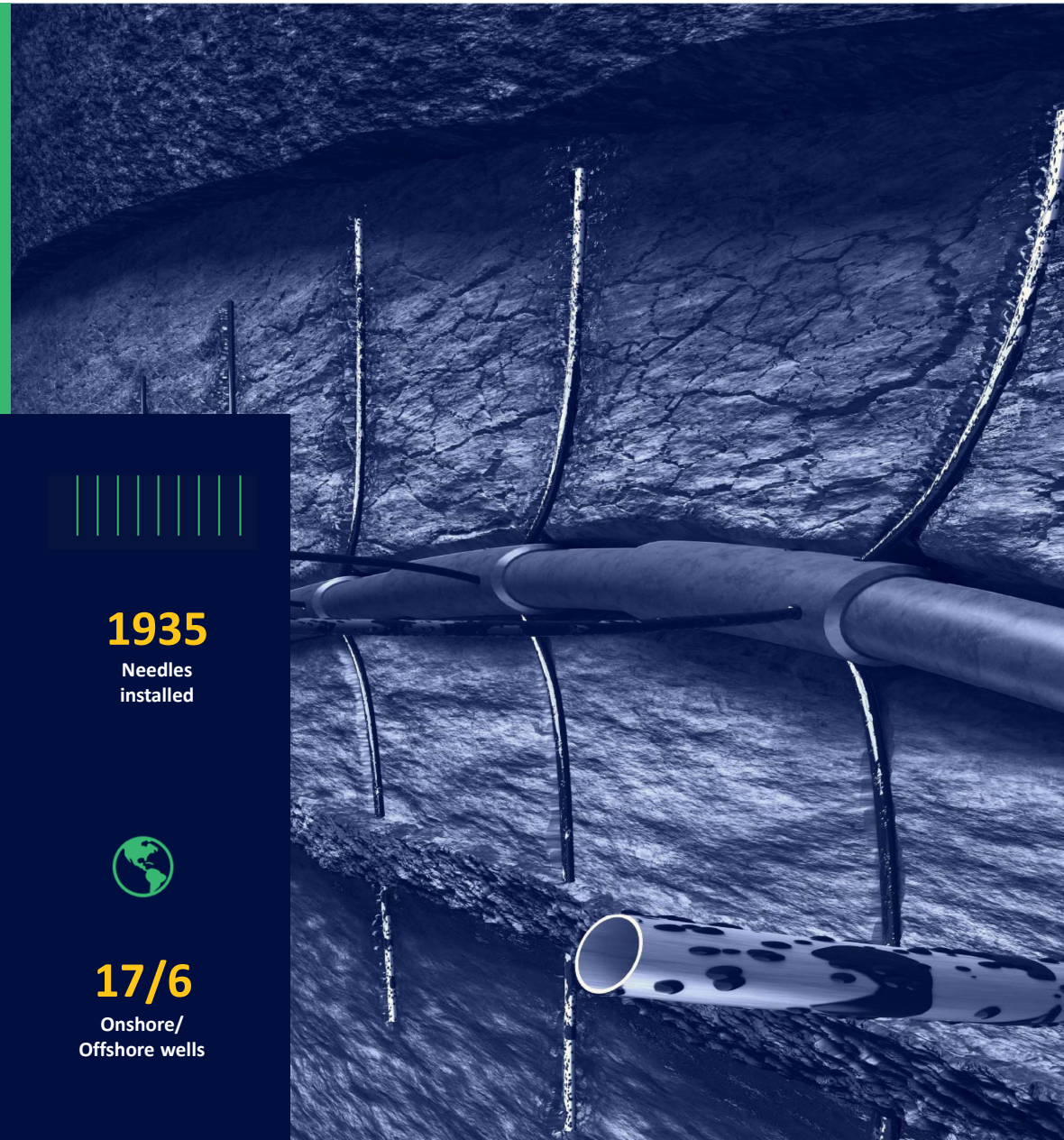
Well case	CO2 emissions (tonnes)		CO2 reduction using Fishbones Drilling (tonnes)
	Fishbones Drilling	Hydraulic Fracturing	
Offshore platform well	2,292	5,549	3,257
Offshore subsea well	4,240	8,459	4,219



TRACK RECORD

Track Record

We continue to extend our geographical reach and increase the number of both on and offshore wells



22

Horizontal wells



50%

Lower CO2 emissions

Compared to hydraulic fracturing



x2

Average increase in production



23

Installations globally to date

*Jetting installations: 20
Drilling installations: 3*



1935

Needles installed

1

Vertical wells



48

Max Fishbones subs in a single run

2012m

Longest horizontal section



3853m

Deepest installation (TVD)



142°C

Highest temperature application



17/6

Onshore/
Offshore wells

APPLICATIONS

Applications to-date

Formations

- Naturally fractured carbonate formations
- Layered carbonate formations
- Chalk formation
- Layered sandstone formations
- Coal bed methane

Well types

- Oil producers
- Gas producers
- Water injectors

Combinations

with other lower completion tools

- Sand screens
- Swellable packers
- Frac sleeves
- Tracers
- Timer shoes

CASE HISTORIES

Case Histories





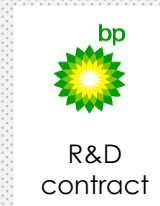
Joint Chalk Research group summary



JCR pilot well program achievements

- JCR project objectives were met
- Fishbones jetting is a proven technology
- Operational procedures established
- Positive contribution to production
- Increased production sustained for 2+ years
- Efficient stimulation
- Developed proven solution for wellbore cleanup
- Numerous lessons learned implemented
- Personnel skills developed

2009



Fishbones for Carbonates development contract

May 2012



Decision point to terminate Valhall pilot well and approach JCR for candidates

Apr 2014



1st well JCR Austin chalk, EnerVest, Texas

Jul 2015



2nd well JCR Buda formation, Blackbrush O&G, Texas

Dec 2016



3rd well JCR Fahud formation, PDO, Oman

CASE HISTORY: NORTH AFRICA ONSHORE INSTALLATION

Fishbones unlocks tight gas (2018)

Challenge

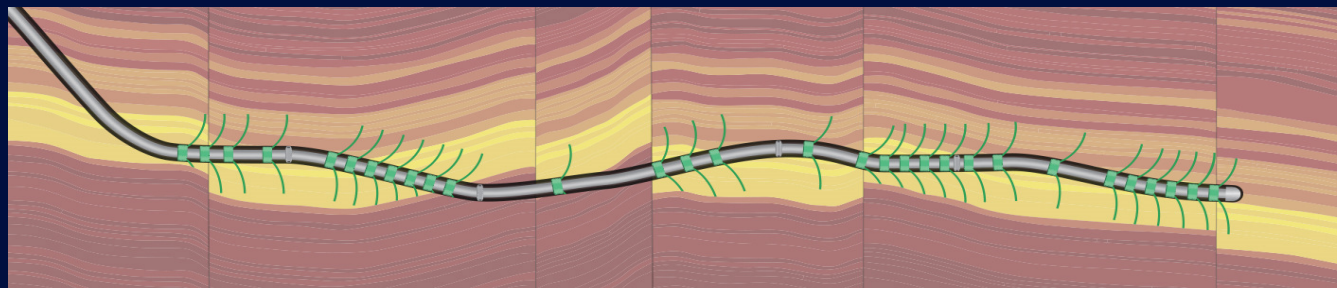
- 1000 meter 6" open hole section in tight limestone formation (<0.5 mD permeability)
- Well partially drilled out of target
- Offset wells were hydraulically fractured, experienced water influx

Solution

- 4 ½" Fishbones liner with 30 Fishbones Jetting subs (120 laterals)

Results

- Gas production rates exceed customer expectations
- 80% higher rates than offset hydraulically fractured wells
- No water production



CASE HISTORY: MIDDLE EAST OFFSHORE INSTALLATION

Fishbones increases PI >4 times (2018)

Challenge

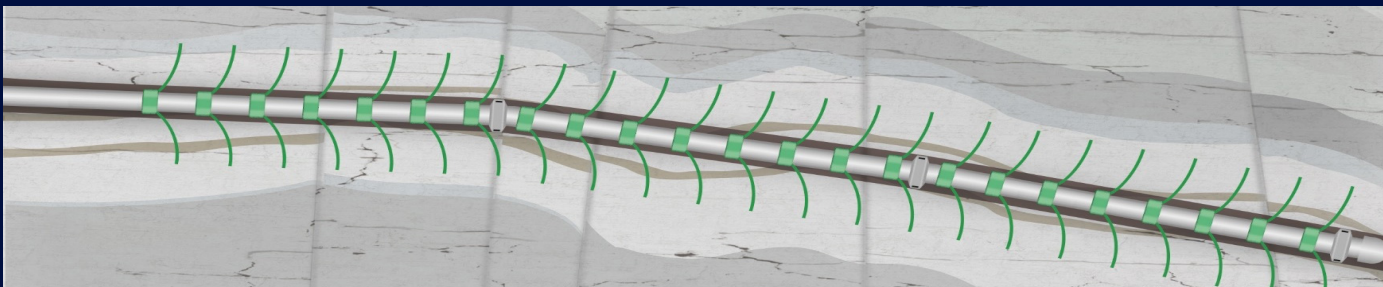
- New well in layered, naturally fractured limestone formation (3 - 5 mD permeability)
- Poor vertical permeability
- Well produced barefoot open hole for 2 months before Fishbones was installed

Solution

- 4 ½" Fishbones liner with 25 Fishbones Jetting subs (100 laterals)

Results

- Oil production increased from ~600 BPD to ~1300 BPD
- PI increased more than 4 times
- Operator placed order for additional six wells
- Global Master Service Agreement signed



CASE HISTORY: MIDDLE EAST ONSHORE INSTALLATION

Step-change in injectivity (2018)

Challenge

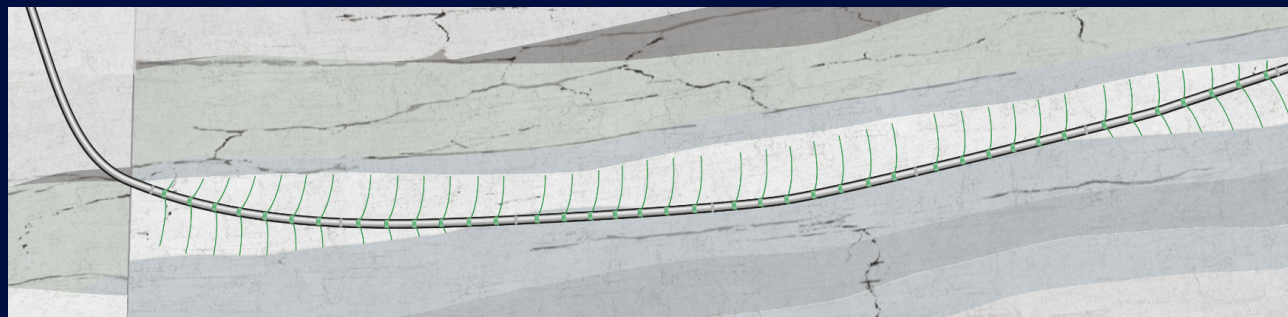
- Existing water injector in tight limestone formation
- Well suffered from poor injectivity: Low injection rates and high surface pressures
- 5m target reservoir thickness

Solution

- 4 ½" Fishbones liner with 40 Fishbones Jetting subs (160 laterals)

Results

- Injection rates increased
- Reduced surface pressures
- SPE paper co-authored with the operator is in the works, to be presented at ADIPEC Nov 2019



Fishbones doubles oil rates (2015)

Challenge

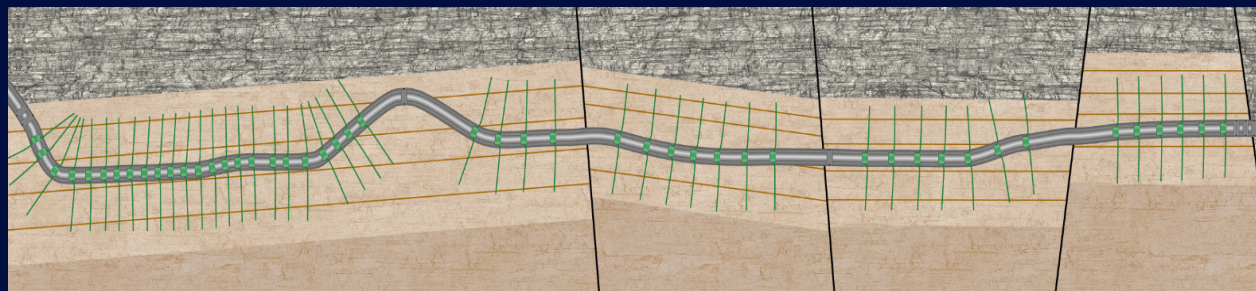
- New well in subsea development
- Tight, layered sandstone formation (0 - 10 mD)
- Vertical flow barriers
- 30 meter reservoir thickness
- Need for accurate stimulation
- Dual lateral well with 2000m / 6600ft 8 ½" horizontals

Solution

- 5 ½" liner with 48 Fishbones Drilling subs (144 laterals) to accurately connect the reservoir
- The downside risk assessed by Equinor to be limited

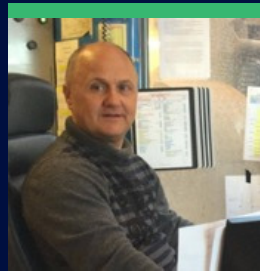
Results

- Equinor interpretation of production log (September 2017) concludes that 2/3 of the production is originating from the main bore i.e. 100% higher production with Fishbones
- SPE-180390
- Equinor awarded Fishbones with TRL7 qualification



CASE HISTORY: NORWAY SUBSEA INSTALLATION

Fishbones doubles oil rates (2015)



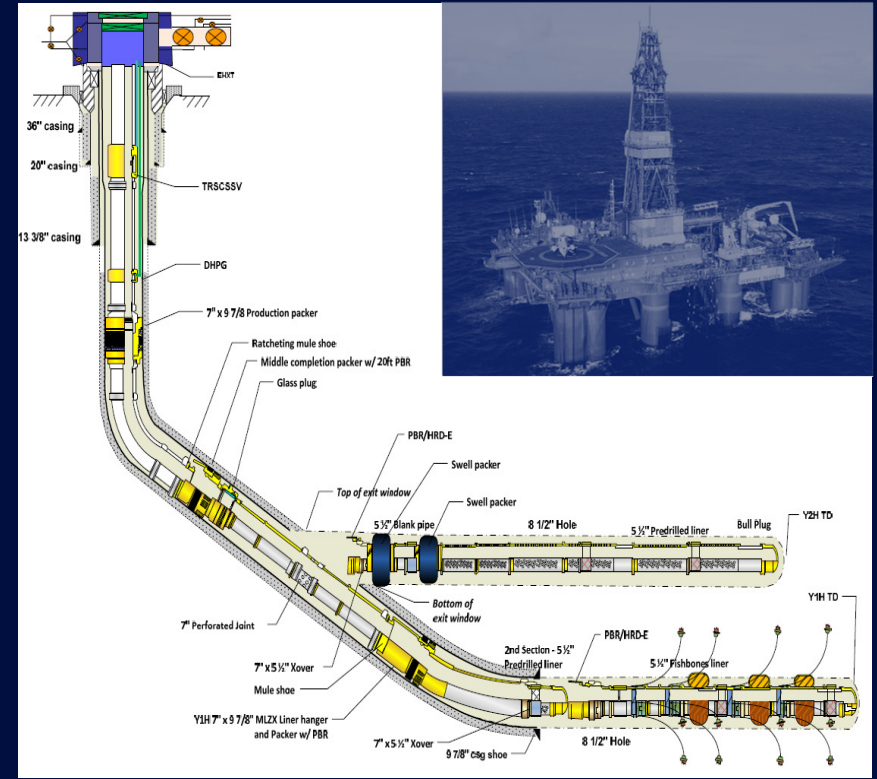
Odfjell Driller, Otto Vabø

“This is the easiest drilling operation I’ve experienced”



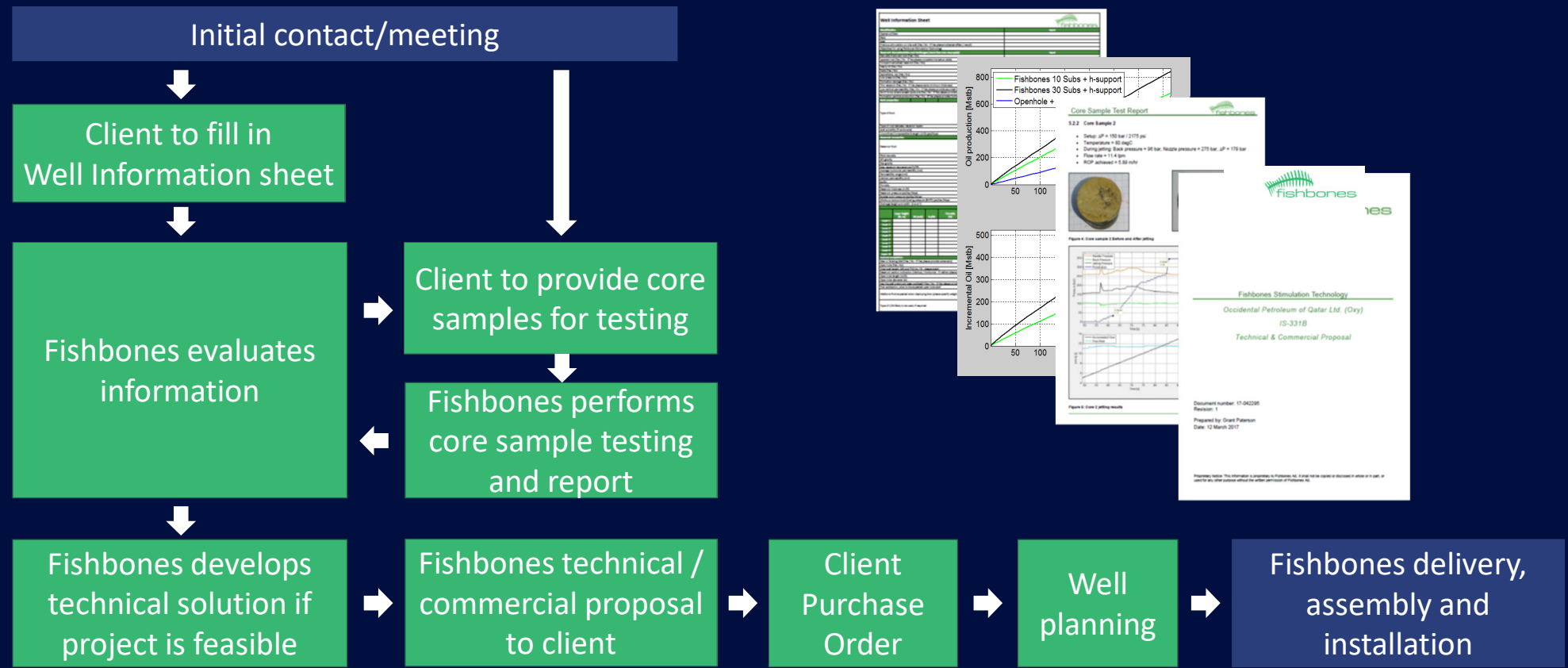
Discipline leader Reservoir Technology, Bård Haukland

“Excellent cooperation with Fishbones before, during and after installation”



HOW WE WORK

Business process



JOB DESIGN

Application evaluation

Review of data

- yes/no

Reservoir simulations

- Fishbones Simfish modelling
- 3rd party reservoir modelling (Fenix)
- Operator performed

Simfish v3.11

Enter Porosity, NTG and saturations as fractions with values in the range [0,1]

	Layer height [ft]	Kh [mD]	Kv/Kh	Porosity	NTG	Pressure [psi]	Sw Irr.	So Irr.
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0


Method: Fishbones JETTING Fishbones DRILLING

How to?
 Switch to Gas Model
 Switch to Injector
 Load Input Deck
 Save Input Deck
 Create Deck & Run

Top Reservoir Depth: 0 ft TVD
 Drainage Length: 0 ft
 Drainage Width: 0 ft
 Well Bore Depth Top: 0 ft TVD
 Well Angle from vertical: 0 deg Specify Depth
 Target Wellbore length: 0 ft
 OH Skin Factor: 0
 OH Wellbore diameter: 0 inch
 BHFP target: 0 psi
 Simulation time: 0 days
 Oil rate limit: 0 bpd
 Pressure support
 Horizontal Vertical
 Excess pressure inj: 100 psi

Eff. Length Lateral: 0 ft
 Eff. Diameter Lateral: 0 inch
 Casing Joint Length: 0 ft
 No. of FB Subs: 0
 No. of FB Laterals: 0
 No. of Joints in well: 0
 One FB Sub per: 0 Joint(s)
 Price per sub: 0 USD
 Fixed FB price: 0 USD
 Oil Price: 0 USD/stb
 Compute STOIP

Dead Oil Model
 Production Scenario
 Oil API Gravity: 0
 GOR: 0 scf/stb Switch to PbP
 Reservoir Temp: 0 F
 Gas Gravity: 0
 Case (ID): Simfish_TEST
 Directory: C:\projects\Simfish\




JOB DESIGN

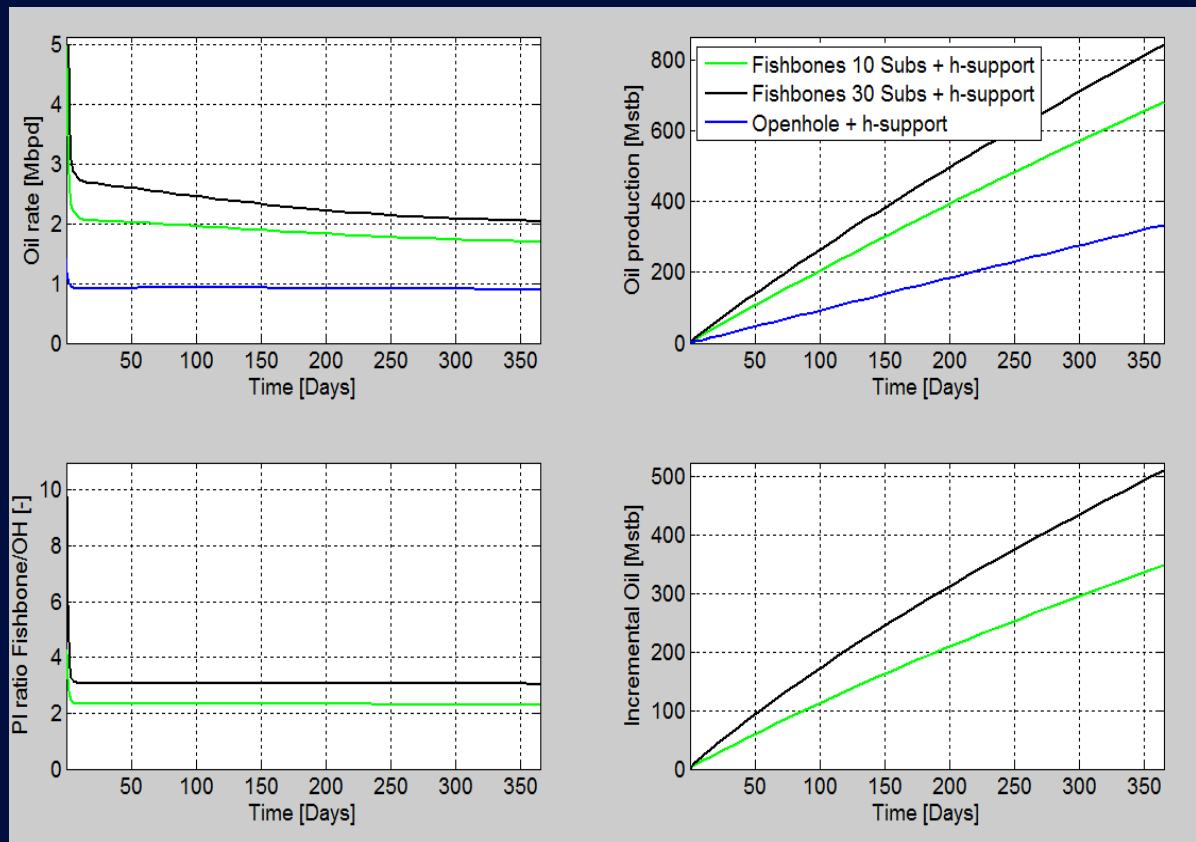
Application evaluation

Review of data

- yes/no

Reservoir simulations

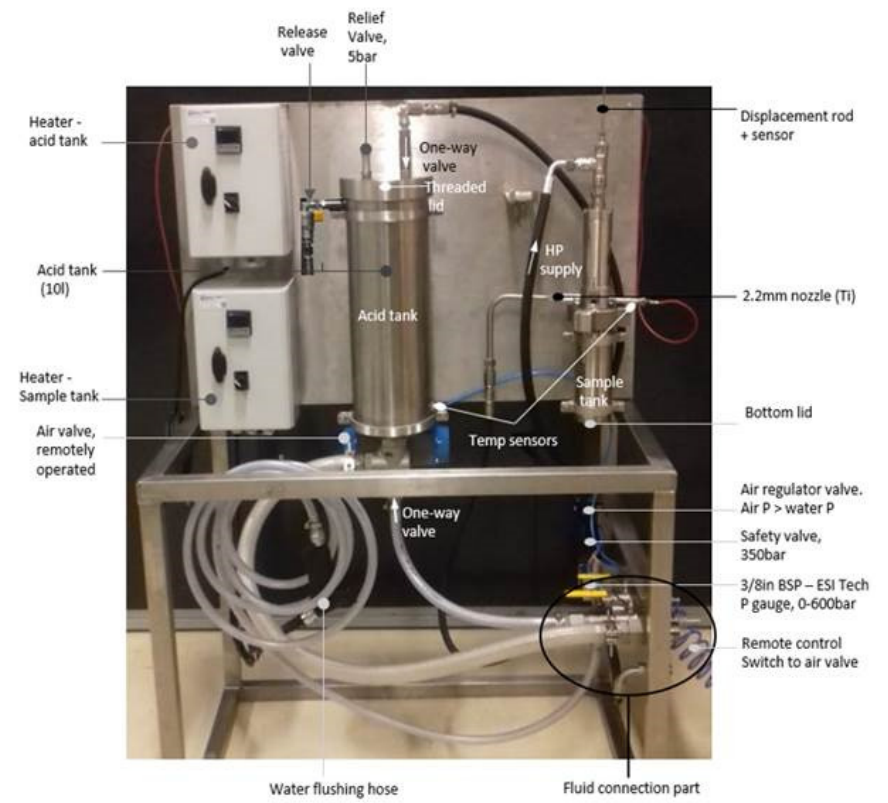
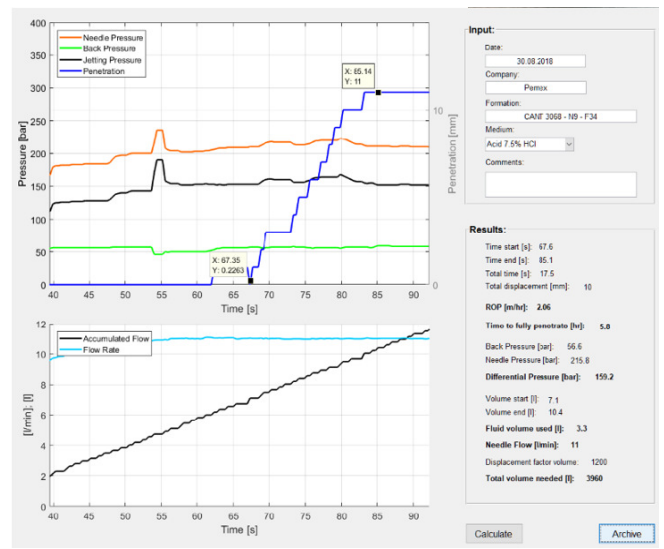
- Fishbones Simfish modelling
- 3rd party reservoir modelling (Fenix)
- Operator performed



JOB DESIGN

Core sample testing

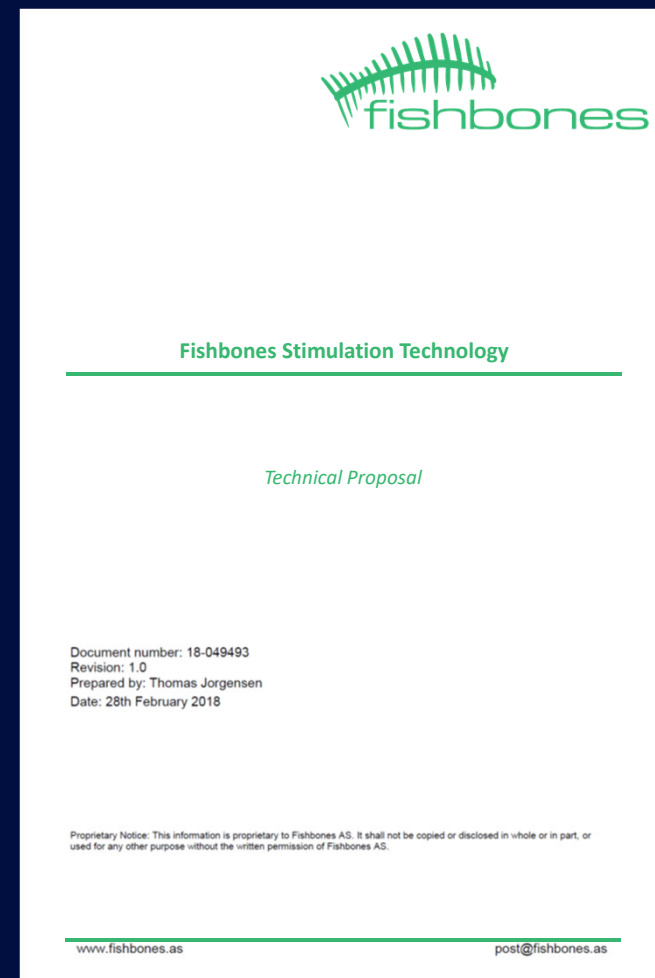
- Performed on all types of formations
- Fishbones testing facility at HQ
- Mobile test units available if cores cannot be exported
- Required core dimensions: 1.5in diameter or larger, minimum 2in length
- Fishbones Jetting: Sample of actual acid is preferred



JOB DESIGN

Technical proposal

- Technology overview
- Reservoir and well considerations
- Core sample testing
- Reservoir simulations
- Technical solution
- Completion schematic
- Hydraulic calculations
- System components details
- Operator supply
- Operational procedures



New Technology Developments

Fishbones with oriented needles

- Needles to only penetrate in desired direction(s)
- Scope is for both Fishbones Jetting and Fishbones Drilling
- JIP started Q1 2019 with Aker BP, Lundin and Neptune Energy
- Scheduled to be ready for field installation Q2 2020

Other

- Fishbones Jetting with particle control (JIP)
- Fishbones Drilling for injection wells
- Fishbones Jetting retrievable on drillpipe
- Fishbasket 1-run





THANK YOU

