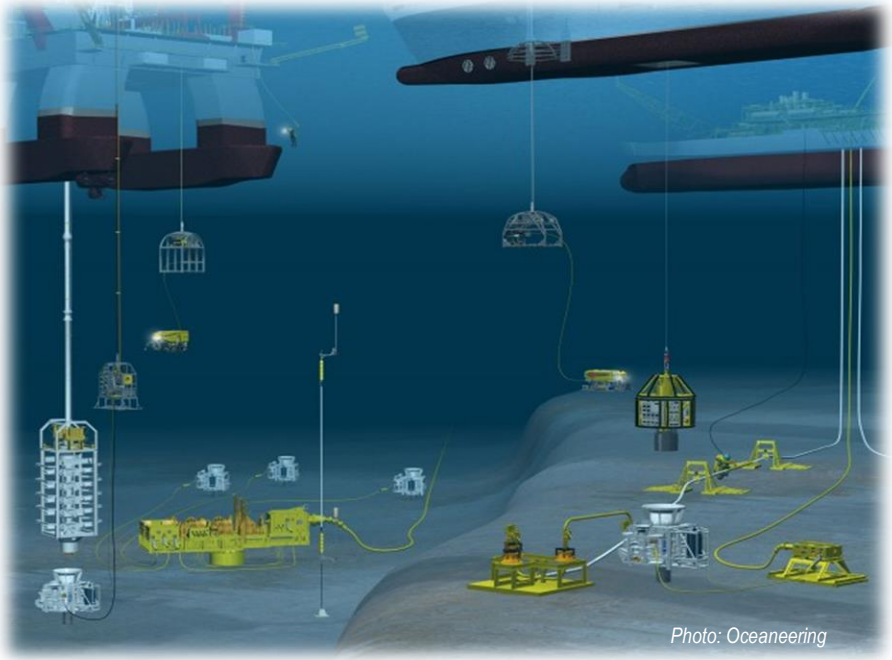


An Overview of Subsea Decommissioning

Presented by:

Bruce Crager

Executive Vice President: Expert Advisory Group

Endeavor Management

Endeavor

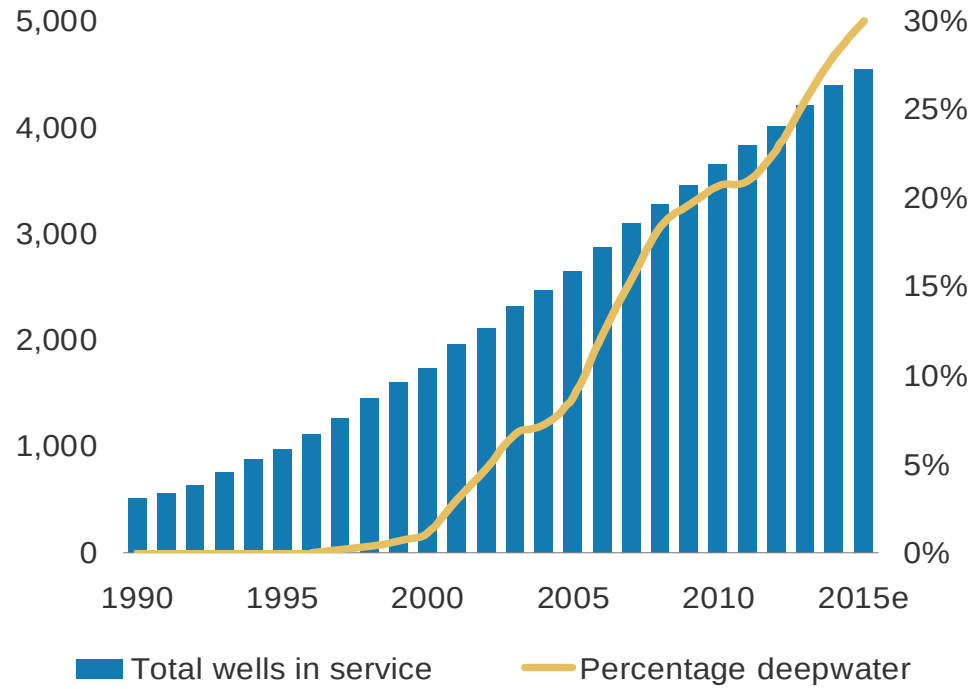
Offshore Decom Is an Active Market

- Offshore decommissioning is a growing market segment because:
  - The number of fixed platforms and floating production systems is increasing
  - The number of subsea and platform wells continues to grow and are generally in decline
  - Lower oil price makes some fields unprofitable
  - Regulatory requirements at cessation of production
- Industry collaboration is required to share best practices and find ways to safely reduce risk and cost of offshore decommissioning.

Subsea Decom is a Growing Issue for the Industry

- The average age of subsea wells is steadily increasing
- Increasing number and older age will result in more subsea decommissioning than in the past
- Regulatory agencies are requiring decommissioning of fields as they become economically nonviable
- P & A of subsea wells is far and away the most expensive single element and fraught with the most risks for subsea decom projects.

Subsea Wells - Number

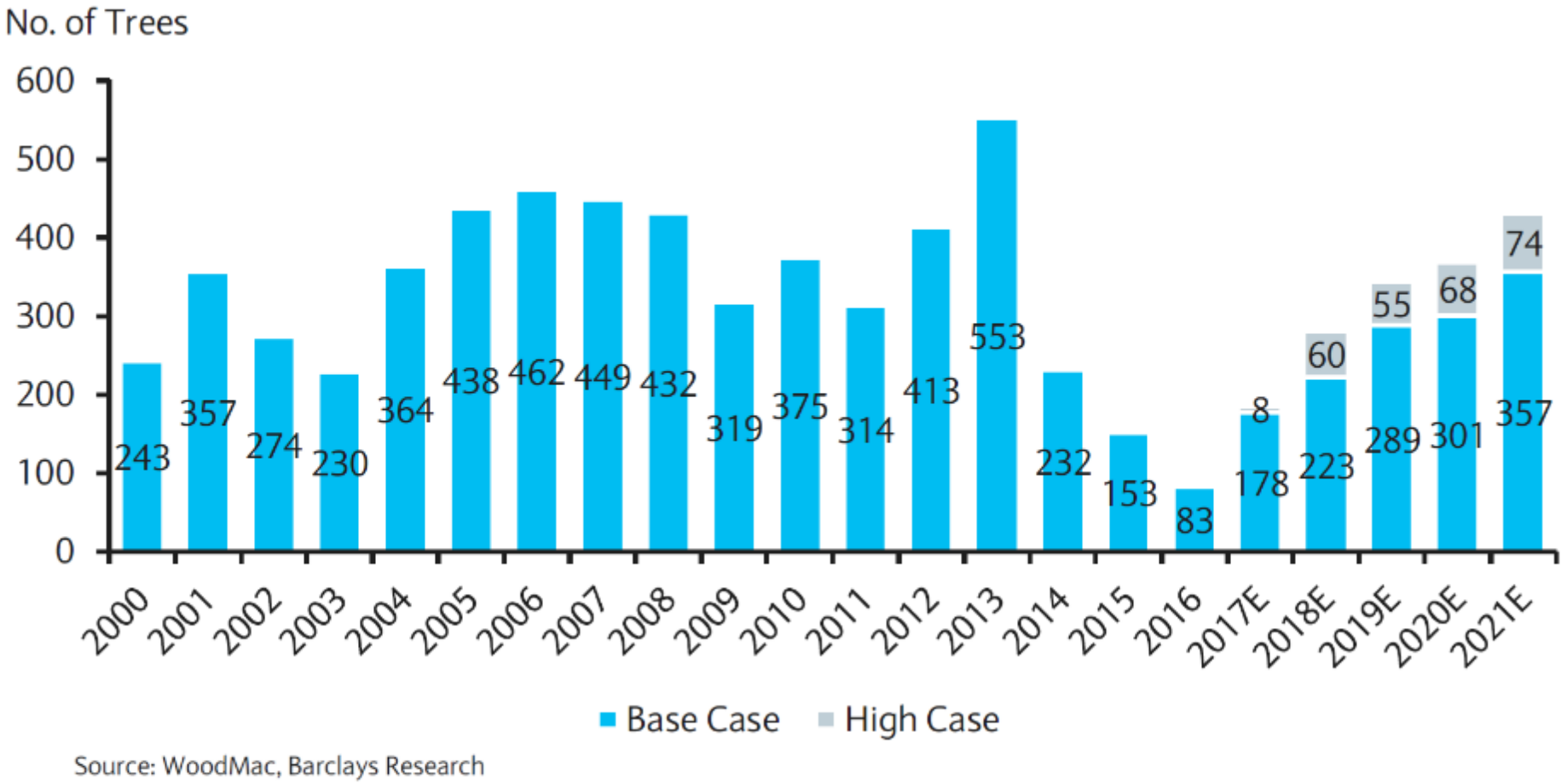


Source: Company Data, Morgan Stanley Research estimates
Note: We are assuming a well is decommissioned after 20 years

- There has been consistent growth in the number of subsea wells since the early 1990's.
- Deepwater wells are increasing and should comprise 30% of total subsea wells by 2015

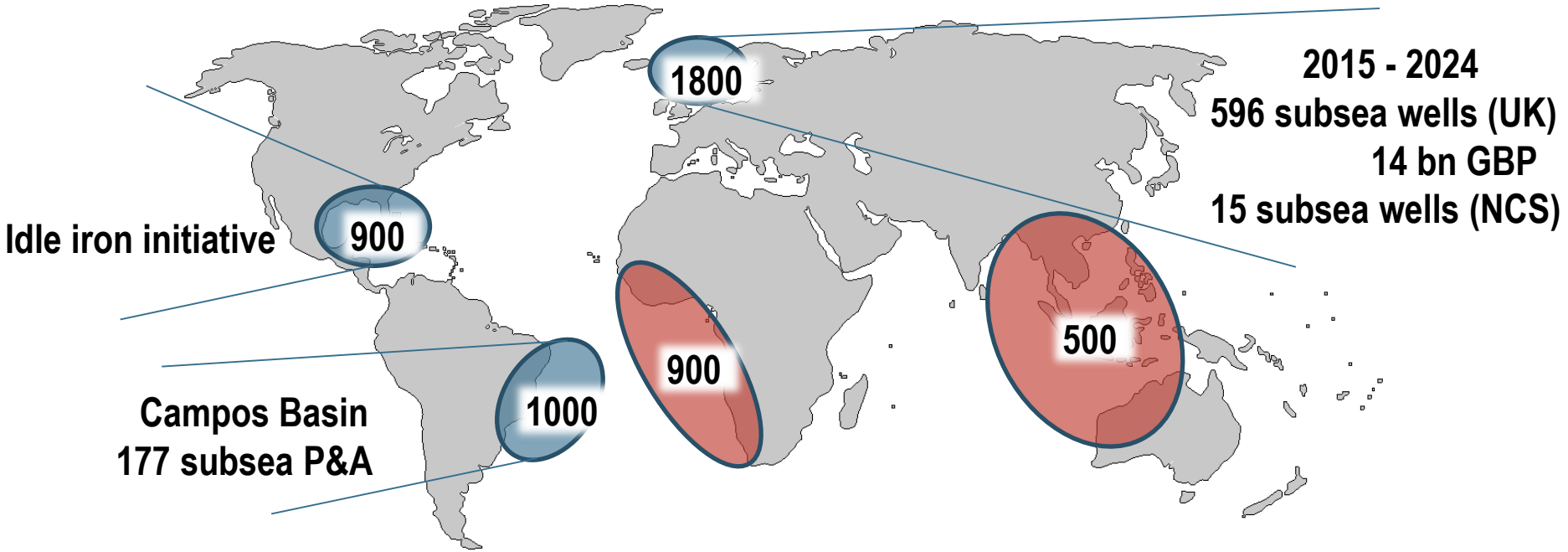
Subsea Tree Awards and Forecast

(Base vs. High Case)



Source: WoodMac, Barclays Research

Subsea Well Population and P&A Market



With permission of SeaNation, LLC

Endeavor's Decommissioning Team

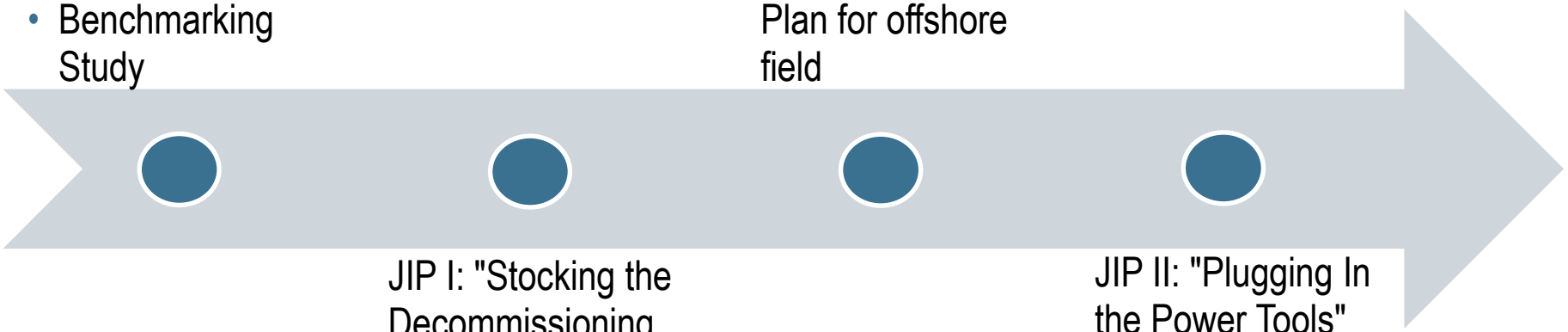
History and Accomplishments

Decommissioning Study for Petrobras 2014-2015

- Worldwide Rules/Regs
- Identify Best Practices
- Benchmarking Study

Deloitte / Mauritania Government: Decommissioning Regulations 2017

- National Oil Company
- Evaluated Decom Plan for offshore field



JIP I: "Stocking the Decommissioning Tool Kit" 2016

- 8 Operators
- 5 Service Companies

JIP II: "Plugging In the Power Tools" 2018

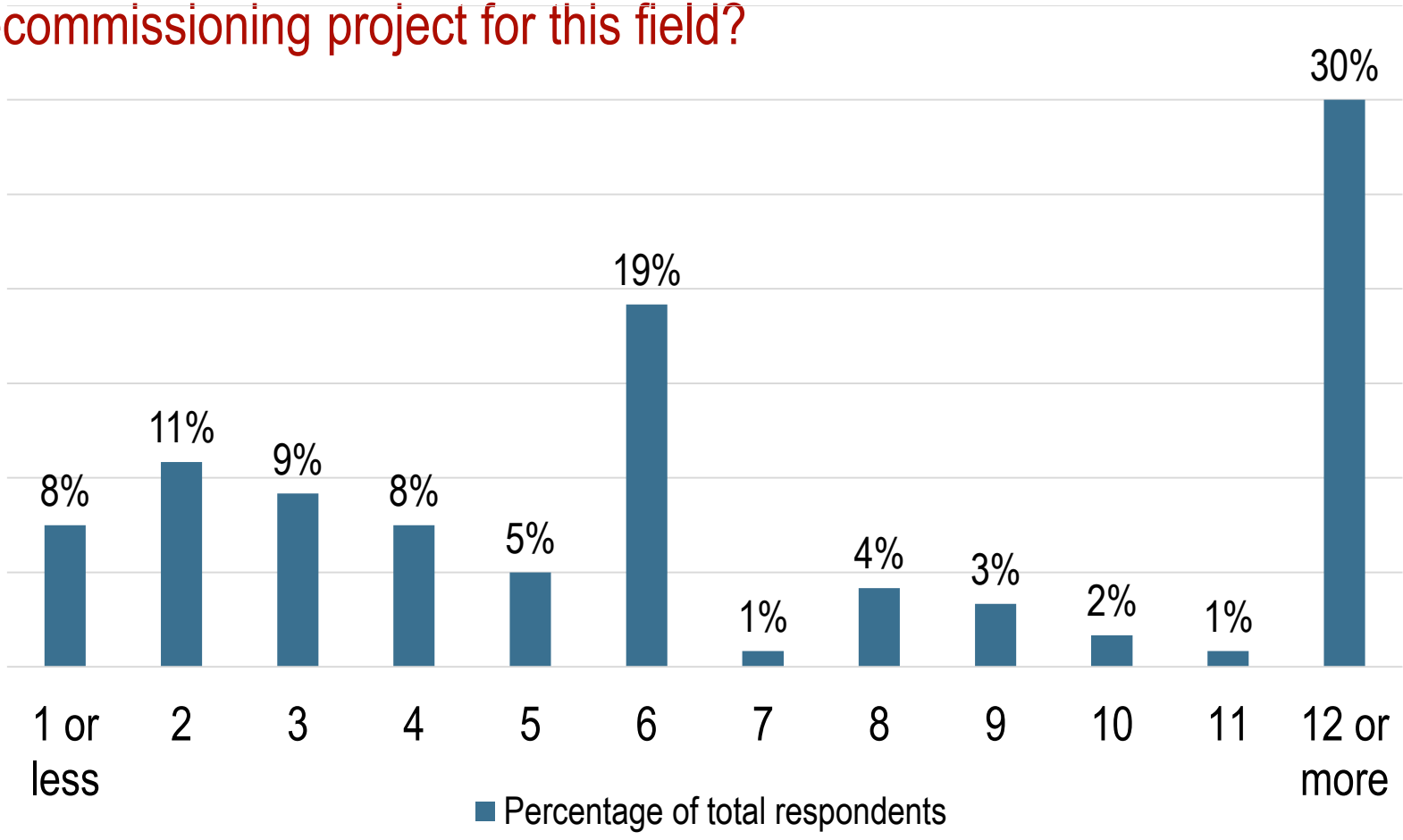
- Proposed
- Cost is $99,000
- 15 Participants

Subsea Decom Study for Petrobras

- Commissioned by Petrobras who were actively planning their future decom activities in Brazil
- Endeavor Management performed the study in 2014 and 2015 in three distinct reports:
  - Worldwide Rules and Regulations
  - Best Practices Quantitative Survey
  - Benchmarking Study with Multiple Operators
    - 2 Majors
    - 1 Large Independent
    - 1 Small Independent
    - 2 National Oil Companies (including Pertobras)
- Precursor to the Subsea Decommissioning JIP - Phase I

Best Practices Survey Results

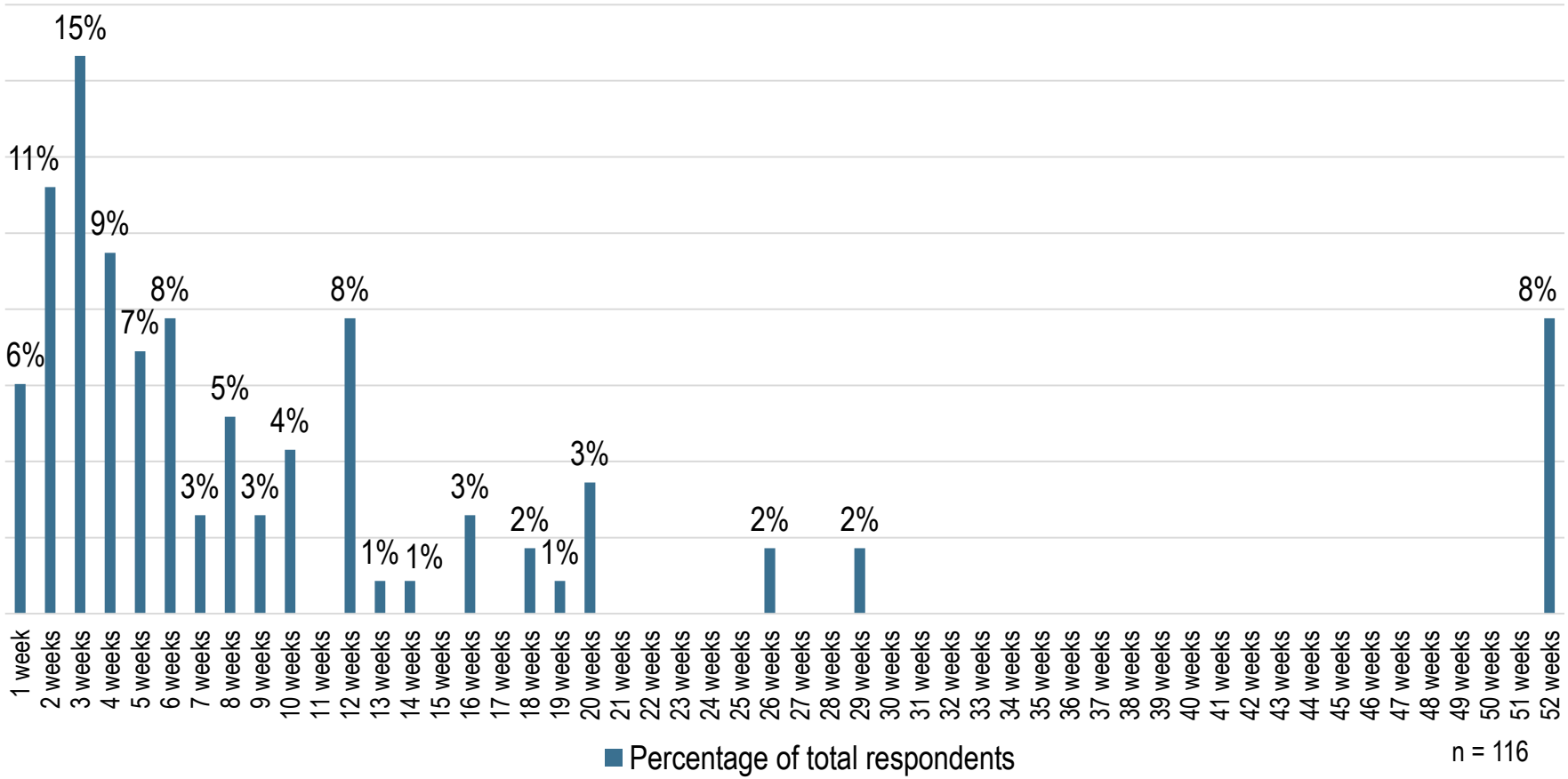
Approximately how many months were required for planning the subsea decommissioning project for this field?



n = 120

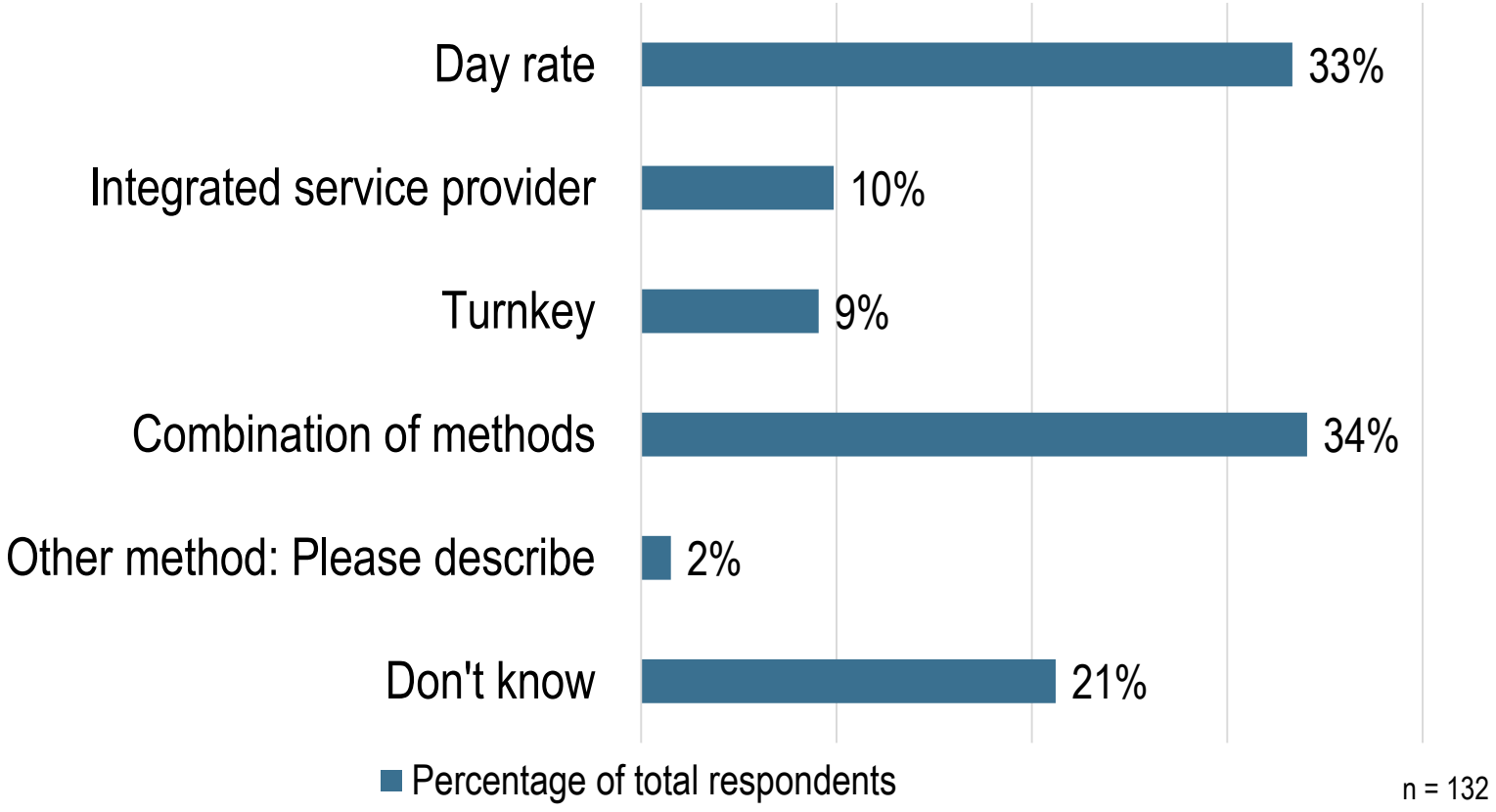
Best Practices Survey Results

How many weeks were required to conduct subsea decommissioning operations offshore for this field?



Best Practices Survey Results

What was the method of contracting used with service providers for this project?

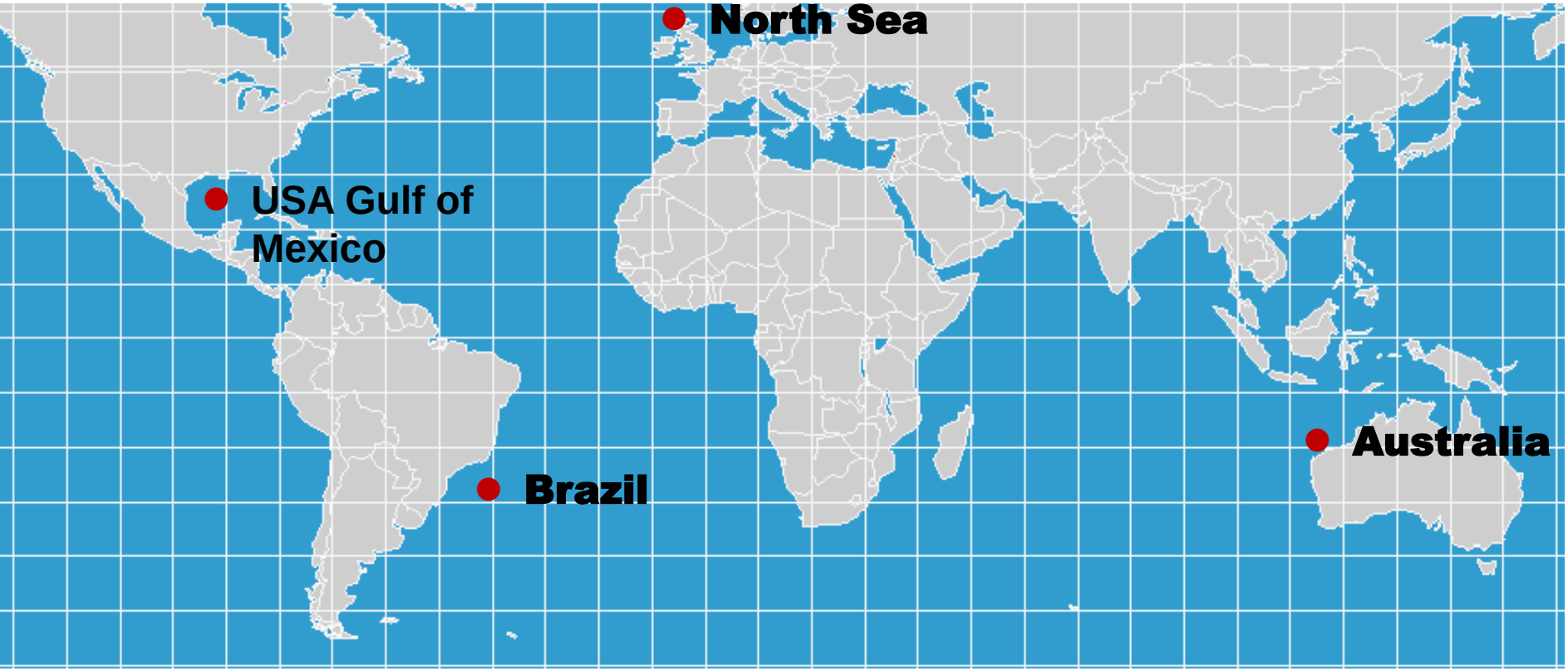


Conclusions of the Online Survey

- Subsea decommissioning is a major area of concern for the industry in the future.
- Costs for subsea decom are difficult to estimate and have a negative impact on Operator economics.
- P & A costs are a significant portion of overall subsea decom costs but this is sometimes mitigated by leaving trees and tubing in place.
- The industry is open to sharing information on subsea decom and recognizes the benefit of finding ways to lower costs.

Decommissioning Study

Benchmarking Data Gathered from These Areas



Decommissioning Planning

- Participating operators all emphasized the importance of planning as a key factor in successful subsea decommissioning.
  - There was evidence that pre-planning for decommissioning (during the initial design phase of the development) can bring significant cost savings during the decommissioning program.
- Data development (gathering historical well information i.e. production, cessation, reservoir, geotechnical, drilling and completion, as built and modifications) is a key success factor in analyzing decommissioning requirements and planning efficient operations.
  - Data development can be done either by experienced contractors or employees

Contracting

- Limit the number of vessels by utilizing those than can support multifunctional services e.g. Survey, Diving, ROV, 100 Ton minimum lift capability.
- Contractual Flexibility with the contractor(s) is paramount for a win/win.
- For Turnkey Contracts the Scope of Work must be clearly defined. Unknown risks will be difficult to quantify monetarily.
- For Fixed Day Rate Contracts there is less risk, but again the Scope of Work must be clearly defined to ensure the crew and equipment requirements are properly identified.
- Both Turnkey and Fixed Day Rates can work with the same contractor by separating the Scope of Work appropriately.

Costs and Key Cost Drivers

- The Benchmark operators provided some excellent representative costs associated with the various operations.
- The actual costs cannot be predicted either overall or by line item due to the large number of variables associated with unknowns.
- Budgetary projections can be developed on a “rule of thumb” basis with contingency allowances added.
- Costs to P&A a single subsea well ranged from $1.1 Million (133 meters WD with Dive Vessel) to over $40 million (1600 meters WD with MODU)

Duration of Offshore Operations

- Majority of Benchmark operators experienced average of 6 weeks offshore.
- Complexities in the number and condition of wells, size of the development and unforeseen weather issues can greatly alter the amount of time spent offshore.
- Important to have all tools ready when needed and backup plan for any tools needed in an emergency.

Vessels

- Larger operators tend to have vessels on contract for a variety of projects, decommissioning being one. Therefore tendency seems to use specialty vessels (ROV, Diving, Heavy Lift, Light Well Intervention, MODU) as part of a campaign during multiple decommissioning projects.
- Smaller operators tend to contract vessels with multiple capabilities and reduce mobilizations/demobilizations.
- Smaller operators also are less risk averse than larger operators and tend to utilize Light Well Intervention vessels in preparation for MODU or to actually complete P & A work when able.

Well P&A Issues

- Some subsea wells are over 40 years old and still on the seafloor
  - Intervention tooling and running tools can be difficult to obtain
  - Information on older subsea wells can be difficult to obtain
- Operators often sell off older assets late in field life to smaller companies
  - Smaller Operators focus on costs and will use the most cost effective vessels they can find
  - This can result in lack of information and needed tools as noted above

Plugging and Abandonment

- P & A is far and away the most expensive single element and fraught with the most risks.
- The use of light well intervention vessels versus drilling rigs has many pros and cons. Large operators tend to use a full service MODU but they also have higher P&A costs.
- When employing a drilling rig for P & A work as a part of the subsea decommissioning program, maximize the efficiencies by using one already on contract and work to undertake all of the P & A tasks as a back-to-back operation.

Disposition of Subsea Components

In the **Gulf of Mexico**:

- Most Operators plan to abandon subsea components in place in water depths deeper than 800 meters.
- Some components are recovered because of potential recycle opportunities such as trees, PLEMS/PLETS, Flying Leads, and UTAs.
- BSEE is now supportive of leaving subsea wellheads in place (subject to fishing and naval issues) in case there a future need for intervention.
- BSEE does not support leaving the tree on the wellhead because it might be difficult to remove in the future.

The **North Sea** region is following the original guidelines to recover everything possible.

Regulatory requirements are less well defined in **other regions** but most require returning the seabed to its “original condition”.

Hydrocarbon Removal

- Majority of flushing operations are with seawater due to economic reasons.
- There is also an environmental consideration to avoid chemicals as part of the cleaning/flushing operation.
- Flushing of flexible components can be problematic due to hydrocarbons in the layers.

Onshore Disposition

- Most Operators have little input or experience with the Onshore Disposition of recovered components
- Facilities are primarily chosen by the Contractors, but must meet all Regulatory mandates for safe handling and disposition.
- Contractors for disposal can be difficult to find. This is a cost driver, anything you pull, you have to deal with the disposal.
  - Can the NORMS be re-injected?
  - How to deal with mercury?

Key Lessons Learned

- Establish an internal Subsea Decommissioning team.
- Plan and then plan some more! Each P&A is unique.
- Do not underestimate the time required to compile and review documentation.
- Conduct an in-depth survey of existing subsea facilities.
- Define the vessel(s) to execute this effort.
  - Define the rigs/vessels that will conduct P&A operations.
  - Define requirements for the vessels that will be removing subsea hardware items from the seafloor.
- Ensure all support vessels and hardware are available.
- Confirm hydrocarbon capture methods and disposal process for all subsea hardware.

After Petrobras Subsea Decom Study

- Petrobras and the Endeavor Team developed a number of questions which were not answered during the Petrobras study
- These questions were developed into tasks for more investigation
- This resulted in a Scope of Work for a Joint Industry Project on Subsea Decom

Stocking the Decommissioning Tool Kit:

Phase I Subsea Decommissioning Joint Industry Project *Completed*

Member Companies in the Project

Operators

- Chevron North America E&P Company
- EnVen Energy Ventures, LLC
- ExxonMobil Production Co.
- Freeport-McMoRan Inc. (FMI)
- Marubeni O&G US (MOGUS)
- Shell Exploration & Production
- Stone Energy Corporation
- Total E&P Research & Technology USA, LLC

Service Companies

- Baker Hughes International / Aker Solutions Subsea Production Alliance
- GE Oil & Gas UK
- Halliburton Energy Services, Inc.
- Oceaneering International, Inc.

Phase I Subsea Decom JIP

Completed July 2016

Issue A:	Intervention Vessel Cost Model
Issue B:	MODU Capability for Non-MODU Price?
Issue C:	Effective Cost and Performance Application of Resins
Issue D:	Decommissioning Subsea Pipelines & Flowlines
Issue E:	Cement Bond Logging Through Multiple Casing Strings
Issue F:	Subsurface Cutting and Milling Options
Issue G:	Well Casing Outer Annuli Access
Issue I:	Dealing with Hazardous Materials
Issue J:	Coiled Tubing in Open Waters
Issue K:	Ecological Benefits of In-situ Decommissioning of Subsea Hardware

Decommissioning Support for Government of Mauritania

- Endeavor was contracted to review the Operator's Decom Plan for the Mauritanian Government
  - Regulatory comparison to worldwide regulations and practices
  - Environmental review related to recovery or leaving hardware in place
  - Plug and abandonment of 15 subsea wells
  - Removal of FPSO as well as laying down risers, umbilical and mooring lines
- Decom Plan Review was completed in April 2017

Phase II Subsea Decom JIP *Start in 2018*

- Prepare an effective subsea Cost Model, stocked with realistic data, for late life liabilities.
- NEBA [Net Benefits Environmental Analysis] – Best-Practices Environmental Comparative Assessment Tool in Making Decommissioning Decisions. 3 Case Studies:
  - Deepwater Subsea in GOM
  - North Sea Jacket
  - North Sea Shallow Water Subsea *(Could change to Brazil)*
- Taking the First Step Forward in Proving Resins' Long Term Durability for Well P&A and Other Interventions.
- Outline ways to gather, store and share oilfield environmental data. Demonstrate how one institution's system for similar data works.

Subsea Decom JIP Phase II

- Eight Focus Areas are Included
- Two International Operators committed, two Smaller Operators have expressed interest to join and mutilple companies considering joining.
- Expected duration for the project is 6 months after kickoff
- Cost is $99,000 per participant with 15 participants (cost may vary depending on final number of participants and agreed scope)
- Results are only available to Funding companies

Decommissioning Worldwide

THE CHANGING REGULATORY CLIMATE

Better Ways to View Decom Value

- Rules require cleanup and closure of oil and gas facilities
- Decommissioning value retention
  - Proactive late-life planning
  - Maximize field recovery
- Reducing amount of decom could increase total recovery
- Royalty relief can encourage more hydrocarbon recovery
- Planning decisions balance
  - Capturing remaining hydrocarbons
  - Delivering a cost-effective decommissioning project
  - What to retrieve vs. what to leave

Rules and Regulations

The United States and the North Sea (UK and Norway) are the only locations with well defined rules for subsea decommissioning

Most other countries require a general “return the seafloor to its original condition“ concept

Recent experience indicates it is better to leave wellheads, subsea hardware and pipelines in place after removing hydrocarbons

- Recovery can do more damage than leaving the equipment in place.
- If a future problem occurs with the wellbore, it is easier to intervene if the wellhead is still in place
- In some locations there is no convenient way to dispose of removed material.

One PRIMARY GOAL for Regulators Worldwide: Do the Best Thing for the Earth.

Source: pngall.com

Two Ways to Achieve This Goal

"Do It One Way"

- Tell the Operator / Liable Company how to decommission via rules and specifications

"Do It the Right Way"

- Allow / encourage the operator to make the Right Choice on a case-by-case basis

The Fundamental Difference Between the Two Approaches

"Do It One Way"

- Specifies results:
- Regardless of facility
- Regardless of site conditions

"Do It the Right Way"

- Specifies the PROCESS used to make the decisions

Why World Attitudes are Changing Toward the "Right Way" Approach

"Do It One Way"

- This philosophy gets you "close" to the best solution.

"Do It the Right Way"

- This philosophy gets you to the Right solution.

The Best Way to Regulate

"Robustness of Process, rather than Prescription of Outcome"

- Install the Best Decision Making System
- Police the System
- Assure that the System is Adhered to, and You Will Get The RIGHT Results

"Comparative Assessment" A system that leads us to the right decommissioning decisions

Alternatives, by component:

- **Remove it**
- **Relocate it**
- **Remediate it**
- **Leave in situ**

- Must choose
  - Greatest benefit to public (Unlike develop, or not)

Comparative Assessment Techniques

- **Qualitative**
  - Green/yellow/red risk assessment
  - Subjective

or

- **Quantitative**
  - More inputs and effort to analyze
  - Data gathering for specific issues
  - Transparent to stakeholders

A Systematic Approach to Environmental Decisions

- Such an approach is in place and available worldwide. It has been used to great success in several industries.
- The generic name for systematic decision-making for the environment is **Comparative Assessment [CA]**.
- Within the CA field, one methodology has emerged as the Leader in effective decision making.
- This system is called **NEBA: Net Environmental Benefits Assessment**.

NEBA Value within Decommissioning Comparative Analyses

- Provides a non-arbitrary, scientific, transparent and quantitative approach to compare between alternative actions
- Helps stakeholders to manage site risks; maximize environmental, safety, social and economic value; demonstrate the net benefit to the public; and manage cost
- Helps document environmental sustainability and stewardship

Mature Regions: Regulatory Status Regarding CA and NEBA

Gulf of Mexico / USA

CA and NEBA are in early stages of use as decision tool. BHP Billiton and Marubeni are leaders in using the NEBA tool in dealing with regulators. The JIP is being reviewed by BSEE and BOEM at this time.

North Sea

CA is more established, but within a prescriptive regulatory regime [OSPAR]. Starting presumption is clear seabed; other results are hard to 'sell.' Regulators are starting to recognize to System-based approaches as opposed to full removal.

Doing What Makes Sense

Why Do We Perform a NEBA?

- A NEBA will maximize ecosystem service benefits to the public while managing site and implementation risks, as well as costs.
- Fundamental Truth about NEBA: One of the Best Ways in the World to Guarantee that YOUR DECISIONS MAKE SENSE.

How Is a NEBA Cost Effective?

- As long as "apples – apples" maintained, only enough detail to effectively compare options is needed.
- Only expend extra effort if two options appear to be 'tied.'
- When one NEBA done in a specific situation, less cost required to perform another in similar situation.
- NEBA can help minimize risk of conflict or delay due to outside stakeholders, especially when inputs to process are shared.

The Power of NEBA

The Effect of NEBA on Comparative Analysis

OUT OF the process:

- Prejudicial Attitudes/ Bias
- Emphasizing past precedence
- Anecdotal & subjective analysis
- Perceived Political Correctness

INTO the process:

- Common sense
- OBJECTIVE & Quantitative
- Systematic analysis
- Analysis over time – not a snapshot

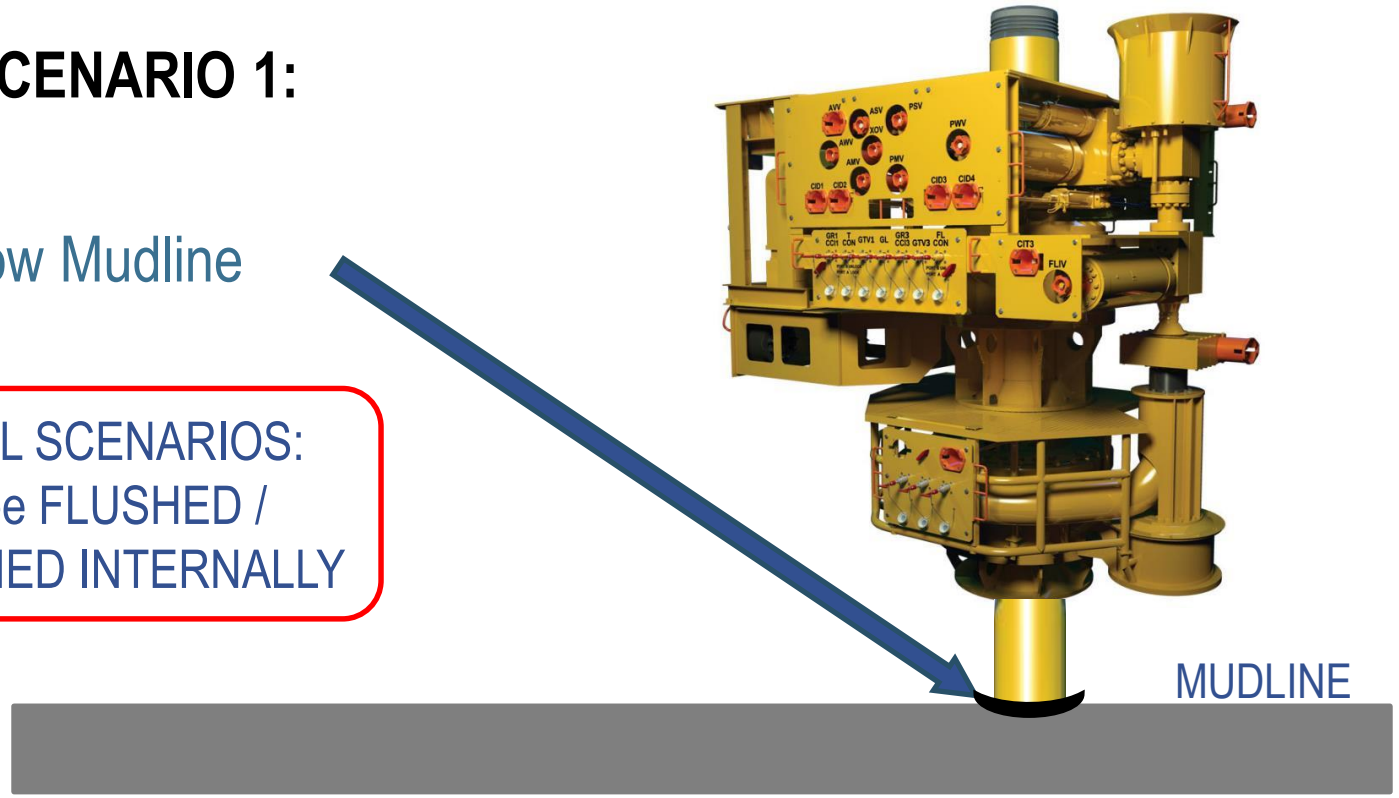
Common Sense Applied to Controversy

Full NEBA Analysis comparing SEVERAL SCENARIOS

TREE SCENARIO 1:

Cut Below Mudline

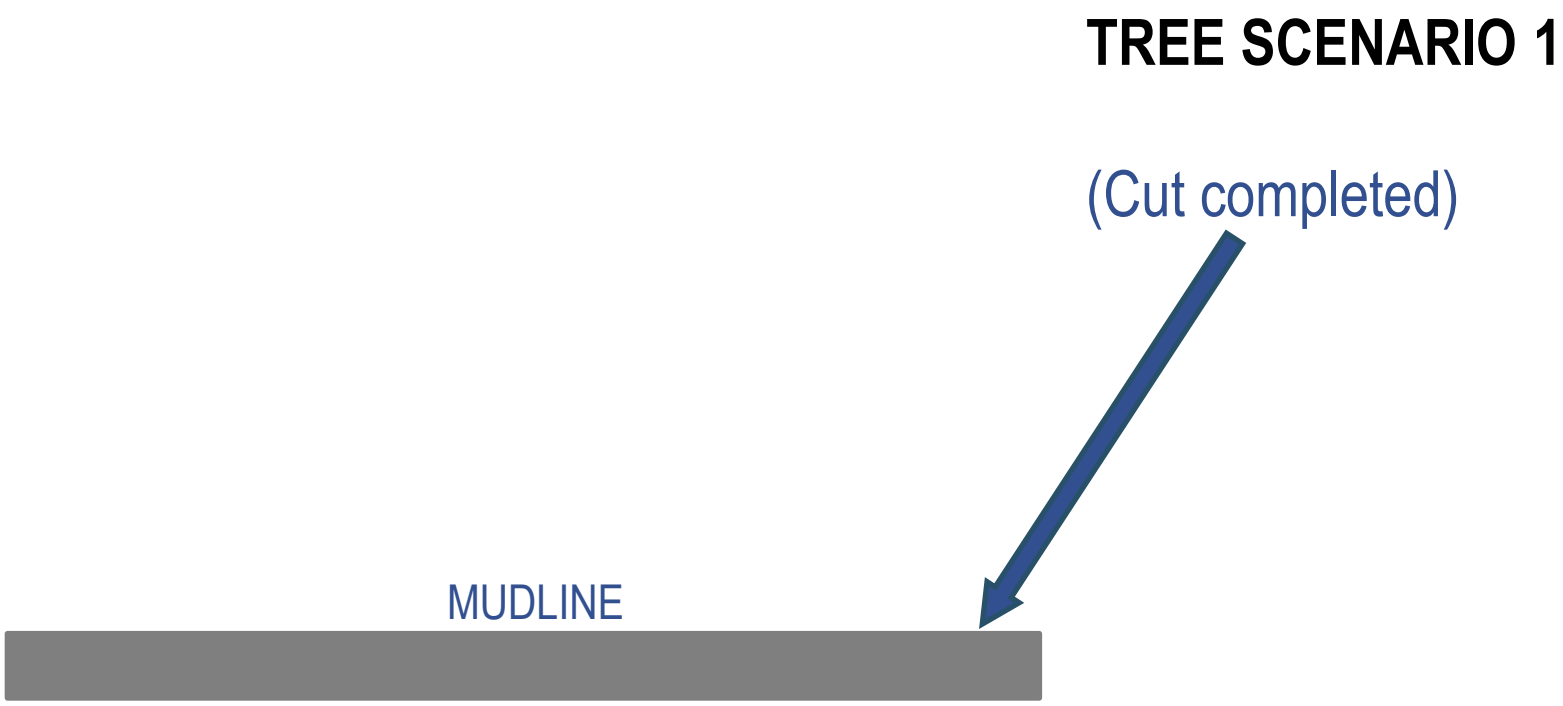
In ALL SCENARIOS:
Tree FLUSHED /
CLEANED INTERNALLY



Source: OneSubsea – drilling contractor.com

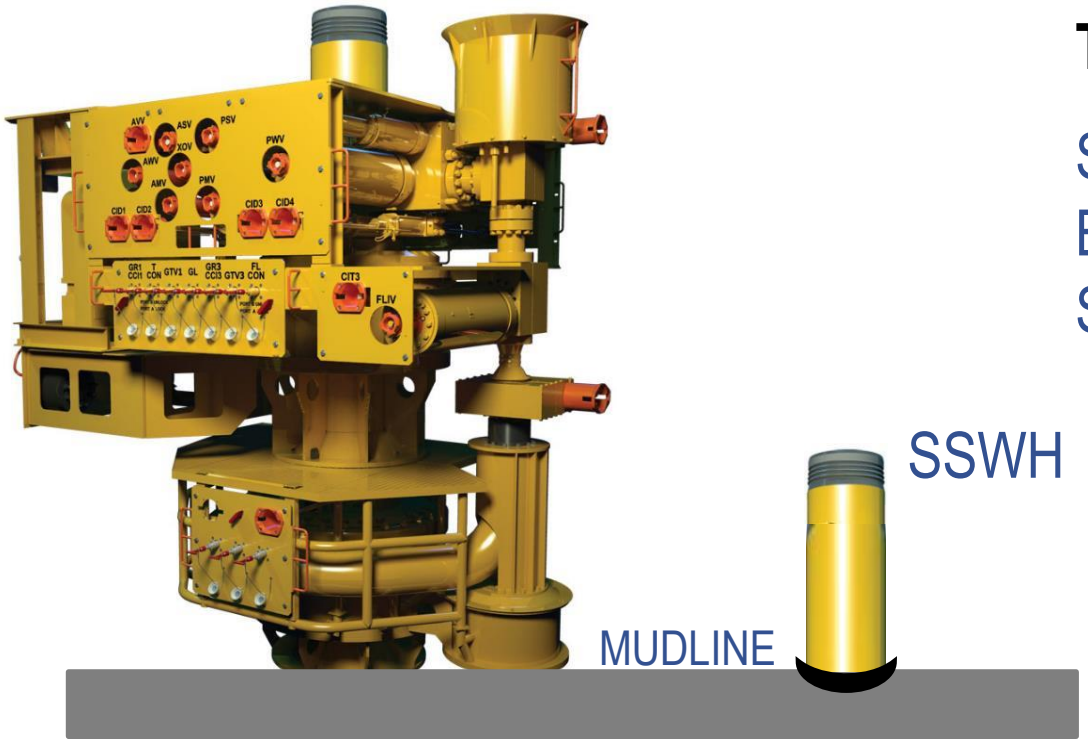
Common Sense Applied to Controversy

Full NEBA Analysis comparing SEVERAL SCENARIOS



Common Sense Applied to Controversy

Full NEBA Analysis comparing SEVERAL SCENARIOS



OneSubsea – drilling contractor.com

TREE SCENARIO 2

Set Tree Aside Onto Sea Bed: Leave Tree and SSWH “IN SITU”

Common Sense Applied to Controversy

Full NEBA Analysis comparing SEVERAL SCENARIOS

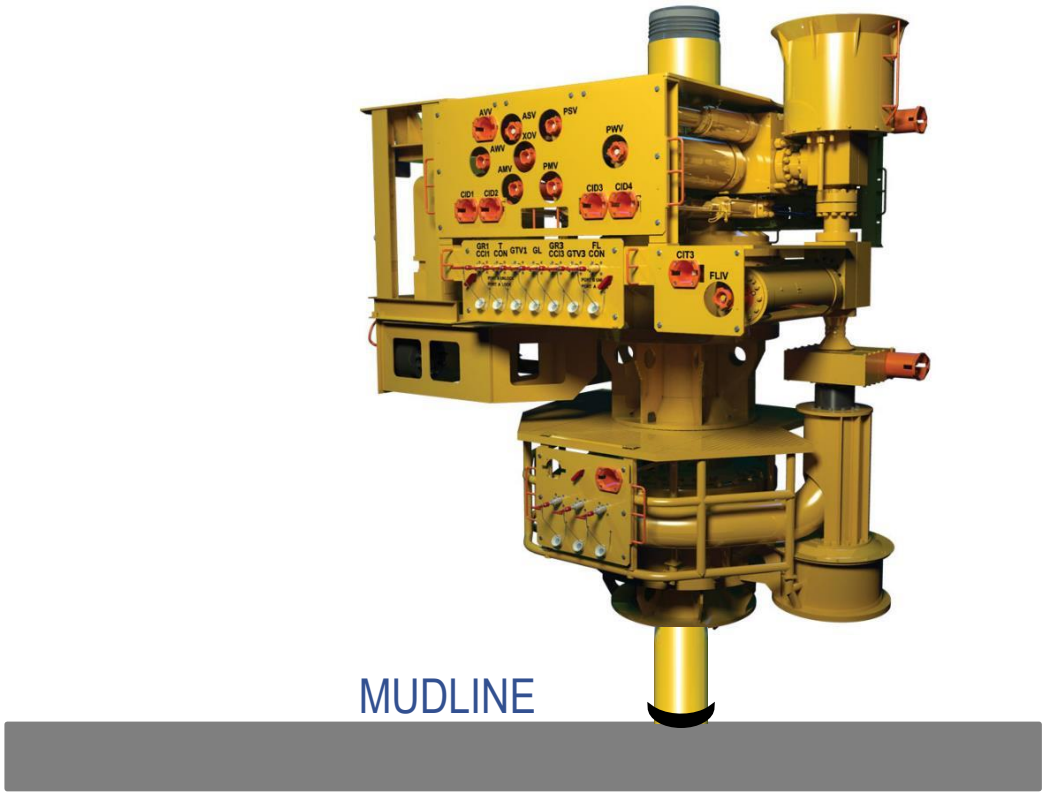
TREE SCENARIO 3

Recover Tree, Leave Subsea Wellhead IN SITU On Sea Bed

Source: OneSubsea – drilling contractor.com

Common Sense Applied to Controversy

Full NEBA Analysis comparing SEVERAL SCENARIOS



Source: OneSubsea – drilling contractor.com

TREE SCENARIO 4:

Leave Tree IN SITU (in place) attached to wellhead atop the Plug & Abandoned Well

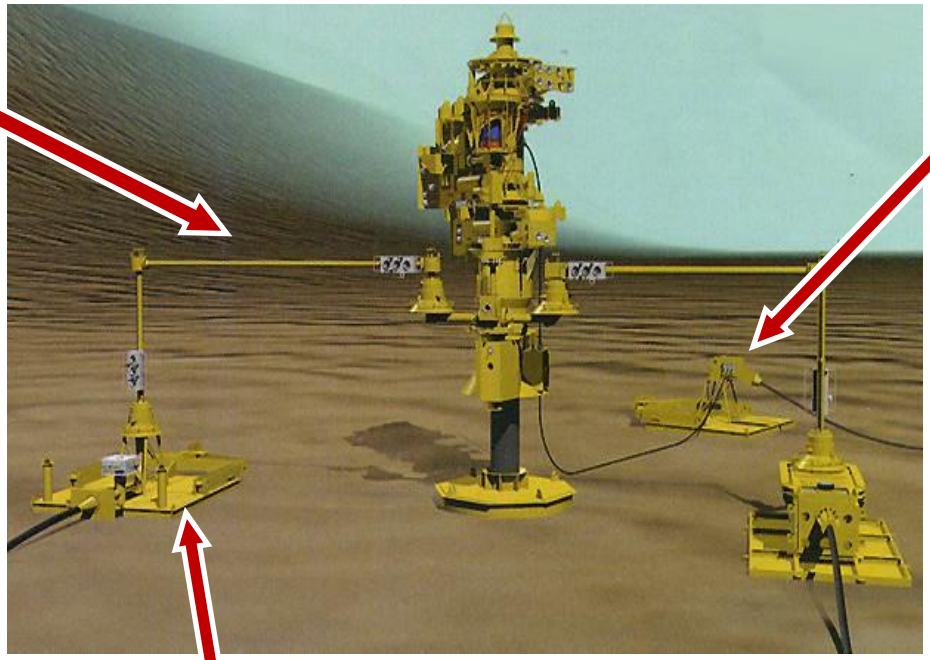
Common Sense Applied to Controversy

Full NEBA Analysis comparing SEVERAL SCENARIOS

JUMPERS

OPTIONS:

- Remove
- Cut Pipe, leave end conns attached



SUTAs

OPTIONS:

- Remove
- Leave "In Situ"

OPTIONS:

- Remove
- Leave "In Situ"

PLETs / PLEMs

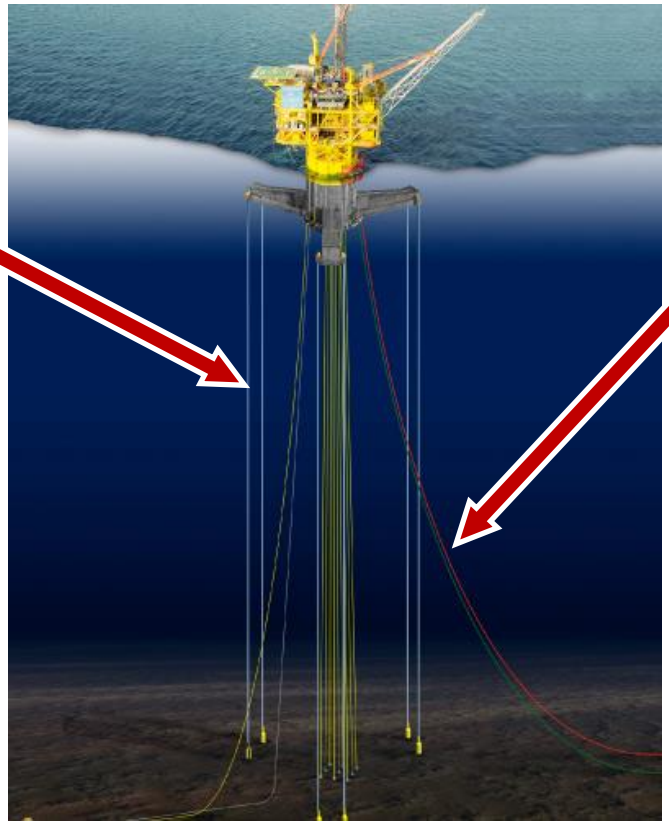
Common Sense Applied to Controversy

Full NEBA Analysis comparing SEVERAL SCENARIOS

MOORINGS / TENDONS

<u>OPTIONS</u>:

- Remove
- Lay Down



Source: Rigzone.com

RISERS

<u>OPTIONS</u>:

- Remove
- Lay Down

In ALL SCENARIOS: Equipment FLUSHED / CLEANED INTERNALLY

Conclusions

- Offshore Decom is a worldwide issue but it is being treated differently in each country
- Full recovery of offshore facilities is not the best solution in many cases
- NEBA appears to be the best type of comparative assessment for any country or project
- Reducing decom costs can increase field recovery
- The industry needs to work jointly to minimize the cost and impact of decom activities to the environment

Questions?

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