Design for Decommissioning
Capturing end of asset lifecycle in oil and gas facility design

Stuart Martin – Sales and Marketing Director, Ardent
Caroline Laurenson – Decommissioning Technical Authority, Xodus Group

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Design for Decommissioning
Capturing end of asset lifecycle in oil and gas facility design

- Statement of Intent
- Benefits
- Synergies
- Progress
- Database Navigation, Structure and Content
- Economic Value
- Guidance Note
- Vision - Next Steps
- Contact Details

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Design for Decommissioning
Capturing end of asset lifecycle in oil and gas facility design

“Begin with the end in mind.”
Stephen Covey

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The D4D Database has been developed to provide feedback from late life and abandonment operations and provides practical guidance to engineers when designing new facilities or modifying existing facilities.

The challenges and issues encountered at the end of a facility’s life may not be foreseen or correctly considered during the design phase. This can make the eventual decommissioning work more technically challenging and costly. The objective of the JIP is to identify decommissioning issues, based on real industry lessons learned and translate these into potential solutions which could be implemented in future designs.
The whole life cycle of the project is considered, with thought also given to late life operations during the design stage.

Promotes a standard approach to incorporating decommissioning requirements into the design.

Economic analysis for project sanction more robust as uncertainty in decommissioning cost estimate is removed.

Opportunities to reduce decommissioning time and cost are evaluated and included in design before construction commences.

Method statement and schedule for decommissioning can be used to predict cash flows in late life of field.

Lower Decommissioning Cost Estimate reduces liability recorded on the company balance sheets.

More accurate estimate of government liability for decommissioning costs.
Design for Decommissioning
Synergies – Bringing Initiatives Together

**Ardent** - jacket, subsea asset and bundles recovery by buoyancy technology

**SUT Salvage and Decommissioning Committee** - Learnings from salvage and marine environmental engineering

**Wood** - Flexible pipes Surflex JIP

**Xodus Group** - Model testing and research into the retrieval of structures from sea bed in conjunction with Dundee University

**OGTC** - Small Pools, infrastructure recovery and re-use

**Oil Company Guidelines** – Field development requirements and decommissioning lessons learned

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Work group: formed in Aug 2016 with thirteen organisations

Initial project scope: boundaries identified – i.e. subsea only

Demonstrated economic value: examined the influence of decommissioning costs in the whole asset lifecycle

Structure for database: defined for use by Lead Design Engineers at the greenfield development define phase

Database populated: input from industry, 82 Lessons Learned captured

Industry guidelines: started preparation to integrate findings and recommendations into the conceptual and FEED phases of the lifecycle

Website: hosted through SPE - Petrowiki

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Design for Decommissioning
Database Navigation & Structure

www.petrowiki.org/Design_for_decommissioning
<table>
<thead>
<tr>
<th>Activity</th>
<th>Initial Cost</th>
<th>Issues</th>
<th>Mitigation</th>
<th>Design Action Reference in Database</th>
<th>Resulting Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineer Down</td>
<td>High</td>
<td>Difficulty with flushing</td>
<td>Define the disposal route for flushing and cleaning liquids</td>
<td>1 and 13</td>
<td>Medium</td>
</tr>
<tr>
<td>Space for flushing equipment on topsides and inadequate access</td>
<td></td>
<td>Improve access from the sea to unstaffed wellhead platform for flushing piping and equipment</td>
<td></td>
<td></td>
<td>Medium</td>
</tr>
<tr>
<td>Provision of flushing liquids to the pipe</td>
<td></td>
<td>Increase diameter of pipe used for chemical injection so it can supply flushing liquids</td>
<td></td>
<td></td>
<td>Medium</td>
</tr>
<tr>
<td>Cost of flushing</td>
<td></td>
<td>Design pigging loops for use during flushing during FEED</td>
<td></td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Moving parts of valves seized</td>
<td></td>
<td>Design pig traps and valves for long term immersion</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Sea bed changes profile during field life</td>
<td></td>
<td>Investigate soil movement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Only part of field being decommissioned</td>
<td></td>
<td>Design Tie in for independent usage of trunk lines whilst flushing</td>
<td></td>
<td>3</td>
<td>Low</td>
</tr>
<tr>
<td>NORM deposited on pipe walls during production</td>
<td></td>
<td>Investigate potential for NORM</td>
<td></td>
<td>4</td>
<td>Medium</td>
</tr>
<tr>
<td>Disposal of cleaning and flushing fluids</td>
<td></td>
<td>Waste water treatment designed for duty during flushing or piping to send fluids to donor wells for injection into the reservoir</td>
<td></td>
<td>14</td>
<td>Medium</td>
</tr>
</tbody>
</table>
Design for Decommissioning
Economic Value

Economic modelling parameters:
- CAPEX
- OPEX
- ABEX
- Tax Rebate
- Discount Rate

Gain in NPV if decommissioning cost estimate is reduced

Example modelling scenarios - goal 8% increase in NPV

<table>
<thead>
<tr>
<th>Options</th>
<th>CAPEX change</th>
<th>ABEX change</th>
<th>OPEX change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decrease CAPEX</td>
<td>8% decrease</td>
<td>No change</td>
<td>No change</td>
</tr>
<tr>
<td>Decrease ABEX</td>
<td>No change</td>
<td>35% reduction</td>
<td>No Change</td>
</tr>
<tr>
<td>Decrease OPEX</td>
<td>No Change</td>
<td>No Change</td>
<td>28% decrease</td>
</tr>
</tbody>
</table>

Source OTC paper 25247 based on Clyde Oilfield Economic model

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The guidance note maps the decommissioning requirements back to the infrastructure components in a series of design considerations.

It will provide a framework to incorporate decommissioning requirements into the design process and include a set of templates and checklists.
Design for Decommissioning
Decommissioning Design Reviews

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**Vision Statement:** Lead Engineers in Design Teams use the information in Option Selection, FEED and Detailed Design

**Next Steps:**
- Further collation of lessons and design solutions
- Refine design of database interface and website
- Guideline document
- Peer review of documentation
- Trialling of database and guideline processes
- Formal publishing of guidance

Expand for other design aspects and infrastructure items such as Topsides & Jackets

Engagement with industry, to provide input, support and feedback

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Opportunity: People across the asset lifecycle working together to build in decommissioning cost reduction measures before an asset has even been constructed.

Call to Action:
- Investigate how your company incorporates D4D
- Feedback on opportunities for improvement and applicability welcomed
- Please feel free to join us or contribute anytime to this no cost JIP, we particularly would like assistance to progress the following:
  - Add to the database with lessons learned for Topsides and Jackets.
  - Help with the development of the guidelines and website.
  - Identification of technology or further research that could support designs which enable more effective decommissioning in future.

www.petrowiki.org/Design_for_decommissioning
Design for Decommissioning
Acknowledgements / Thank You / Questions

<table>
<thead>
<tr>
<th>Name</th>
<th>Role</th>
<th>Contact Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alan Stokes</td>
<td>Project Initiator, Data Collation and Economic Analysis</td>
<td><a href="mailto:alan.stokes@advisian.com">alan.stokes@advisian.com</a></td>
</tr>
<tr>
<td>Stuart Martin</td>
<td>Project Initiator, Facilitator</td>
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</tr>
<tr>
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</tr>
</tbody>
</table>

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Subsea Virtual Reality and Technology Innovations

Moya Crawford (Deep Tek/SOI Group) Joel Mills (Offshore Simulator Centre)
Mark Lawrence, (ADUSDeep Ocean)
International Salvage & Decommissioning Committee

In 2016 the IS&DC organised itself into three sub-committees. Integration is maintained through shared initiatives and support from SUT.
Interaction between Environmental Forces, Ambient Conditions, Ecosystems and Human Activity -

Shared Vision: engineers, scientists, technologists and other interested parties to be able to share the same dynamic picture of the complex interactions at play.
We must be looking towards the future...

Invisible platforms

Shared goal: makes 'subsea factories' reliable, safe, enhancing and profitable
Getting our thinking in order...

What do we mean by 'decommissioning' - and is dismantling and demolition always necessary?
Man-Made Structures on/in the Seabed: two key determinants - materials and surrounding environment (above the Vasa)
LIFT, POWER & CONSTANT SIGNALS
SUPPLIED TO 3000M, USING A DP1, VOO. ONLY POSSIBLE DUE TO PRINCIPLES-BASED INNOVATION AND THE WINDER SYSTEMS' MINIMAL WEIGHT & FOOTPRINT.

**ss Persia**

We had to make the change to synthetic filament rope and vessel of opportunity, if we wished to continue our specialist discipline of cargo recovery. All work was carried out on ‘No Cure/No Pay’!
World's First Soft Rope Knuckleboom Cranes
110t in air / 110t @ 3000m

More about People themselves, than the Technology they help create...

Used our recovery experience to introduce new technology for Installation
Virtual Prototyping HMPE Rope in a Knuckle Boom Crane

How best to use Simulated Performance Data in Technology Qualification?

Deep Tek believes that Simulation should be used from the outset, as an integrated part of the design and Technology Qualification process...Through operational planning....

HMPE rope data was logged in each one metre section of rope at one second intervals. This simulation proved that the crane was the limiting factor in use - not fatigue endurance of the rope. This UNDERSTANDING now drives the engineering design of the integrated system and cuts the Technology Qualification costs - as over-testing is removed.
Underpinning Philosophy

D'Arcy Thompson Simulator
University of St Andrews

Arts & Humanities + Science, Technology, Engineering & Mathematics (STEM) + Finance & Commerce

A Holistic, Lifetime Approach to Wealth Creation

© Maya Crawford 2016
Collaboration with the Offshore Simulator Centre, Norway
Thank you!

If you break the law of gravity the penalty is hanging.

Great Lies to Tell Small Kids, by Andy Riley

Moya Crawford
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m: +447740589916
www.deeptek.no
Simulation the key to the digital revolution
Joel Mills CEO
Creating world leading simulators

It is easy to know what a good simulator is... You forget you are in one.

1. Rich environment (Real equipment / amazing visuals, depth of field)
2. Real physics
3. Most importantly linking together real people.
What is the big change in simulation...

In the past you had to chose.

1. Real physics which could be days of computer processing.
2. Real time with gaming physics.

TODAY
Real Simulation,
In real time
A new world...
Allowing Virtual prototyping.
Using simulation tools for:

- To go beyond what is possible in real life
If a Image is worth a thousand words what about a simulation...

- The visual system used by humans has evolved over millions of years to process imagery in **parallel**. Processing and evaluating massive amounts of information.

- Data and text is relatively new to the human brain and we can only scan a **single** part of text or data at one time.
Simulation is no longer training... It saves Money and time NOW.

1. OSC Verification tool
   - Proof it is possible

2. ONBOARD Simulation
   - Common Understanding

3. Remote observation centres
   - Streamlined installation

- Challenges
  - Uncertainty of operation

- Job
  - Reduced cost
  - Speed of operation
  - Trust in solution
The future is now..

OK.. lets build it and try this out..

In weeks not years at no risk..

All in a virtual world. Then we can try different equipment, setups procedures
the sky is the limit.
University of St Andrews: Collaboration with the Offshore Simulator Centre, Norway
Thank You

Joel Mills CEO  jam@osc.no
Industrial Strategy Challenge Fund:

Wave 3 Expression of Interest

Strategic Priorities Fund
Background to ISCF Wave 3

• UKRI are running an open Expression of Interest (EOI) call to identify Challenges for ISCF Wave 3, delivering on the commitment in the Industrial Strategy White Paper.

• The EOI process will enable industry to fully engage with the ISCF, including those businesses or sectors that do not traditionally make use of innovation funding. The open process also gives us the opportunity to identify novel or transformative challenges that might otherwise be missed.

• The EOI process will be managed by UKRI using Innovate UK’s Innovation Funding Service (IFS)

• The following slides contain information about:
  • the timeline and criteria for shortlisting ISCF Wave 3 Challenges
  • how UKRI colleagues can support ISCF Wave 3
ISCF Wave 3 timeline

28 Feb 2018*: open call for Expressions of Interest launches on IFS
18 April 2018: open call for Expressions of Interest closes on IFS
November 2018: shortlist of Challenges recommended by UKRI to ministers
April 2019: Funding expected to begin for first successful Wave 3 projects

* Likely date - subject to confirmation of ministerial announcement
Making the case for future challenges

• Expressions of interest for Challenges for Wave 3 of the Industrial Strategy Challenge Fund programme must:

  1. Be industry-led
  2. Demonstrate clear alignment with at least one of the Grand Challenges in the Industrial Strategy White Paper:

     • Clean Growth;
     • Ageing Society;
     • Future of Mobility;
     • Artificial Intelligence & Data Economy
Expressions of interest for Challenges for Wave 3 of the Industrial Strategy Challenge Fund will be evaluated by UKRI based on the following criteria:

- Challenge is compelling, focused, and articulated in a way that anyone will understand and see the benefit of solving
- It is industry-led in an area of existing UK strength
- It takes advantage of our research depth and expertise
- There is a clear opportunity for growth with a sustainable global market and contribution from industry
- Evidence indicates that Government intervention is necessary and of strategic importance to the UK
- Evidence indicates that solving the challenge will catalyse productivity growth
Out of scope activities:

• Expressions of interest for Challenges for Wave 3 of the Industrial Strategy Challenge Fund programme **must not be:**
  
  • ‘Business as usual’ – it should be clear why using the Industrial Strategy Challenge Fund to support this area would represent a step change compared to what is currently happening
  
  • Bids for more money – ISCF will not be used to extend the life, or increase the scale, of current activities
EOI Stage: Questions


• Expressions of Interest will be submitted via a form on IFS requesting high-level information in the following sections:
  • Challenge summary
  • Challenge overview
  • Opportunity for productivity growth
  • Market opportunity
  • UK strengths & competitive advantage
  • Industry pull
  • Need for ISCF support
  • Level of funding needed
Strategic Priorities Fund (SPF)

Common research fund c. £100m to support cross/multi-disciplinary low TRL research

• Identify and back new strategic or emerging priorities
• Incentivise and fund multi-disciplinary and inter-disciplinary research and innovation across the system
• Bids must fall into one or more of the following criteria…
  • Multi-disciplinary and inter-disciplinary programmes identified by researchers and businesses at the cutting-edge of research and innovation.
  • National strategic priorities
  • Strategic cross-cutting R&D areas aligned with Government priorities
Strategic Priorities Fund (SPF)

Current Planning
• Hydrogen (generation and modelling as an energy vector).

• Decommissioning
  • Life Cycle Design
  • Life Time extension
  • Reuse of Infrastructure Assets
  • Recycling and circular economy
  • Finally… Decommissioning and disposal.
DeepOcean have developed and are continually improving the methodology for production of 3D point clouds and 3D (Mesh) surface models from the still and video images, using photogrammetry techniques.

These datasets represent the next generation of survey deliverables:

- High density 3D point clouds (colourised)
- Surface models (Mesh)
3D Models from Imagery
Dynamic subsea laser survey methodology is fast & effective - reducing deployment time compared to alternative solutions, and is ‘contactless’ – negating the need for any structural components and dimensional control during metrology work.

Laser data creates a highly leverageable data environment with a long lifetime – offering ‘value for money’ for the client - one laser dataset can provide:

- Metrology – high accuracy, repeatable data;
- Asset inspection – detailed metrical data, ability to see change over time;
- Full contextual 3D survey – greater understanding of assets by seeing a complete picture;
- Reverse Engineering – laser data can be used to create precise models to inform remedial engineering.
When 3D laser data is combined with emerging visualisation technology such as Virtual Reality and Augmented Reality, there is a paradigm shift in the way we can view and understand the character & nature of assets subsea. We are currently only scratching the surface of what this 3D data can provide in terms of information & risk mitigation for our clients. Potential areas for use of Virtual Reality using metrical 3D laser data include:

- Virtual prototyping in preparation for subsea interventions;
- Virtual operational simulations to reduce risks during actual operations;
- Virtual inspection;
- Providing a basis for remote operations in the future;
- Improving contextual awareness & efficiency of ROV pilots;
- Enhanced visual asset management;
- Improving client communication: collaborative virtual reality meetings viewing datasets at 1:1 scale.
This is a VR preview for testing and development only. It may experience some slight turbulence and then explode. Do not use for daily browsing.
VISUAL ASSET MANAGEMENT
Assessing Decommissioning Options for Oil and Gas Infrastructure and their Potential Impacts on the Integrity of MPAs and the Provision of Ecosystem Services (DECOM-MPA)

Dr Daryl Burdon

Senior Ecological Economist, Institute of Estuarine & Coastal Studies (IECS), School of Environmental Sciences, University of Hull, Hull, HU6 7RX

E-mail: D.Burdon@hull.ac.uk – Twitter: @DarylBurdon

Design for Decommissioning Workshop, Dynamic Earth, Edinburgh, Tuesday 6 March 2018
Oil and Gas – Innovation Programme

Daryl Burdon\textsuperscript{1}, Michael Elliott\textsuperscript{1}, Suzanne Boyes\textsuperscript{1}, Anita Franco\textsuperscript{1}, Steve Barnard\textsuperscript{1}, Krysia Mazik\textsuperscript{1}, Teresa Fernandes\textsuperscript{2}, Valentina Ricottone\textsuperscript{2}, John Hartley\textsuperscript{3}, Becky Hitchin\textsuperscript{4}, Matt Smith\textsuperscript{4}, Maria Alvarez\textsuperscript{5}, Alex Fawcett\textsuperscript{5}, Larissa Leitch\textsuperscript{6}, Mark Shields\textsuperscript{7}, Sarah Dacre\textsuperscript{7}
Background to the DECOM-MPA Project

<table>
<thead>
<tr>
<th>Scheme</th>
<th>Innovation Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of call</td>
<td>Oil and Gas</td>
</tr>
<tr>
<td>Principal Investigator</td>
<td>Prof Mike Elliott</td>
</tr>
<tr>
<td>Lead institution</td>
<td>Institute of Estuarine &amp; Coastal Studies (IECS), University of Hull</td>
</tr>
<tr>
<td>Project title</td>
<td>An evidence-based approach for the effects of decommissioning options on Marine Protected Area conservation and ecosystem services (DECOM-MPA)</td>
</tr>
<tr>
<td>Project length</td>
<td>01/02/2017 – 31/01/2018 (12 months)</td>
</tr>
<tr>
<td>Total funds awarded</td>
<td>£168,908.30</td>
</tr>
</tbody>
</table>

Presentation Themes:

1. Complexity of Decommissioning in MPAs
2. Analysis of Complexity of Decommissioning in MPAs
3. Challenges and Future Work
1. Complexity of Decommissioning in MPAs

Key Questions to be Addressed

1) What oil and gas structure(s) require(s) decommissioning?
2) What are the appropriate decommissioning options for the site?
3) What potential decommissioning activities are required?
4) What pressures are likely to result from decommissioning activities?
5) What MPA features are present within the site?
6) What is the potential loss or damage to the designated features?
7) What is the potential for the loss or gain of ecosystem services?
8) What is the potential for the loss or gain of societal goods/benefits?
The DAPSI(W)R(M) Problem Structuring Framework pronounced “dap-see-worm”!

<table>
<thead>
<tr>
<th>Element</th>
<th>Relevance to Decommissioning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drivers</td>
<td>Legal and societal demand for a clean, safe, productive, diverse and healthy environment</td>
</tr>
<tr>
<td>Activities</td>
<td>Appropriate decommissioning options and their associated activities e.g. removal of rigs, burying or removal of pipelines, removal of rock protection, etc.</td>
</tr>
<tr>
<td>Pressures</td>
<td>Wide-scale pressure list: above-water noise, abrasion, siltation, collision risk, contamination by chemicals, litter, light, etc.</td>
</tr>
<tr>
<td>State changes</td>
<td>Potential biological loss, gain or damage to the hydrodynamics, ecology, ecosystem services, such as smothering of the benthos, re-suspension of sediments and re-liberation of contaminants</td>
</tr>
<tr>
<td>Impacts (on Welfare)</td>
<td>Potential loss or gain of societal goods and benefits; commercial, recreational and cultural aspects, such as increase or decrease in fisheries, changes to recreation near developments.</td>
</tr>
<tr>
<td>Responses (as Measures)</td>
<td>Management measures such as legal controls, technological advances or economic instruments to further enhance the provision of ecosystem services; mitigation and/or compensation measures to minimise effects</td>
</tr>
</tbody>
</table>
Questions (Q)

Q1: What oil and gas structure(s) require(s) decommissioning?
Q2: What are the appropriate decommissioning options for the site?
Q3: What potential decommissioning activities are required?
Q4: What pressures are likely to result from decommissioning activities?
Q5: What MPA features are present within the site?
Q6: What is the potential loss or damage to the designated features?
Q7: What is the potential for the loss or gain of ecosystem services?
Q8: What is the potential for the loss or gain of goods/benefits?

Resources (R)

R1: Inventory of available decommissioning options (#3)
R2: Activities-Pressures matrix for decommissioning (#2)
R3: Inventory of protected features in UK marine waters (#1)
R4: Assessment of feature sensitivities to Pressures (#1)
R5: Intermediate ecosystem services (IES) – MPA matrix (#1)
R6: Goods/Benefits (G/B) - MPA matrix (#1)
R7: Underlying scientific evidence relating to decommissioning in the marine environment (#3)
### Scope of the Decision Support Framework

<table>
<thead>
<tr>
<th>What does the decision support framework do?</th>
<th>What does the decision support framework not do?</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Feed into the Environmental Impact Assessment, Comparative Assessment or Derogation cases</td>
<td>✗ Replace the Environmental Impact Assessment, Comparative Assessment or Derogation cases</td>
</tr>
<tr>
<td>✓ Focus on environmental impacts</td>
<td>✗ Incorporate safety, societal, technological and economic aspects</td>
</tr>
<tr>
<td>✓ Facilitate decision-making</td>
<td>✗ Make decisions</td>
</tr>
<tr>
<td>✓ Provide a transparent, defendable, more streamlined approach</td>
<td>✗ Generate new data or evidence</td>
</tr>
<tr>
<td>✓ Provide flexibility to evolve</td>
<td></td>
</tr>
<tr>
<td>✓ Take an innovative natural capital approach</td>
<td></td>
</tr>
<tr>
<td>✓ Allow for review of existing evidence</td>
<td></td>
</tr>
<tr>
<td>✓ Provide an approach which links existing frameworks and tools</td>
<td></td>
</tr>
<tr>
<td>✓ Formalise/simplify current assessment methods</td>
<td></td>
</tr>
</tbody>
</table>
Q1. What Structure?
Q2. What Options?
Q3. What Activities?
Q4. What Pressures?
Q5. What Features?
Q6. Effect on Features?
Q7. Effect on Services?
Q8. Effect on Benefits?
R1. List of Options
R2. Activities-Pressures Matrix
R3. List of Features
R4. Feature Sensitivity
R5. IES-MPA Matrix
R6. G/B-MPA Matrix
R7. Underlying scientific evidence

Drivers: (D)

Activities: (A)

Pressures: (P)

State changes: (S)

Impacts (on Welfare): I(W)

Responses (as Measures): R(M)

• Impacts on Conservation Objectives;
• Mitigation to reduce impacts;
• Reconsider decommissioning options;
• Enhance gains in goods/benefits.
Vessel Movements
Embedment Anchoring
Suction Anchoring
Survey Sampling
Over-trawl Survey
Making Safe
Rig Placement
Rig Removal
Detachment of Topside
Digging out of Infrastructure
Placing of Stabilisation Material
Removal of Infrastructure (Cuttings, Explosives)
Removal of Infrastructure (Pipelines, Jacket Footings)
Re-injection of Cuttings
Concrete Gravity Based Structure Remain in Place
Footings Remain in Place
Burnt Matress Remain in Place
Pipeline Trench and Ditch Remain Open
Pipeline Rock Dump
Pipeline Open Trench Remain Open
Cutting a Trench
Seabed Prep. Corridor for Pipeline
Drill Cuttings Un-disturbed
Drill Cuttings Disturbed

Assess the potential impacts of decommissioning with regard to Conservation Objectives
Reconsider selected decommissioning options to reduce potential impacts
Apply mitigation measures to reduce negative State changes and Impacts (on Welfare)
Introduce management measures to further enhance gains in goods/benefits

Benthos
Physico-Chemical
Shellfish
Marine Mammals
Seabirds

Goods/Benefits from Provisioning Ecosystem Services
Goods/Benefits from Regulating Ecosystem Services
Goods/Benefits from Cultural Ecosystem Services
| Activity                                                                 | 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    | 11    | 12    | 13    | 14    | 15    | 16    | 17    | 18    | 19    | 20    | 21    | 22    |
|------------------------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Common to all decom scenarios                                          | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     |
| Embedment Anchoring                                                    | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     |
| Suction Anchoring                                                      | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     |
| Survey sampling                                                        | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     |
| Overtrawl survey                                                       | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     |
| P&A Making safe                                                        | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     |
| Rig placement                                                          | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     |
| Rig removal                                                            | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     |
| Detachment of top side                                                | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     |
| Digging out infrastructure (excavation around jacket footings, pipeline sections, risers etc.) | -     | -     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     |
| Placement of stabilisation material                                   | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     |
| Removal of the infrastructure (cutting / explosives)                   | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     |
| Removal of the infrastructure (pipelines, jacket footings (non-derogation), risers, mattresses (impact on seabed)) | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     |
| Rejection of cuttings                                                  | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     |
| Concrete Gravity Based Structure (remaining in place)                  | -     | -     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     |
| Footings (derogation) (remaining in place)                             | -     | -     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     |
| Buried mattresses (remaining buried)                                   | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     |
| Pipeline trenched and buried (remaining as buried)                     | -     | -     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     |
| Pipeline rock dump                                                     | -     | -     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     |
| Pipeline open trench (remaining open)                                  | -     | -     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     |
| Cutting a trench (trenching a surface pipeline)                       | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     |
| Seabed preparation (corridor for pipeline)                             | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     | -     |
| Drill cuttings (undisturbed)                                           | -     | -     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     |
| Drill cuttings (disturbed)                                             | -     | -     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     |
## 2. Analysis of Complexity of Decommissioning in MPAs

<table>
<thead>
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<td>Decision Framework</td>
<td>Bernstein et al. (2015)</td>
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<td>PLATFORM</td>
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<td>STARFISH</td>
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<td>FEAST</td>
<td>Marine Scotland (2018)</td>
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<td>ES Matrix Approach</td>
<td>Saunders et al. (2015)</td>
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<td>SPIDA</td>
<td>Current paper</td>
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</tr>
</tbody>
</table>
2. Analysis of Complexity of Decommissioning in MPAs

SPIDA: Screening Potential Impacts of Decommissioning Activities

1: Selection of decommissioning approach

- Infrastructure selection
  - Select class of infrastructure: Platforms
  - Select specific infrastructure type: Platform jackets

2: Decommissioning objective
- Select decommissioning objective: Full removal

3: Decommissioning method
- Select decommissioning method: Multiple lifts using a shear-leg barge or smaller HLV

Select to:
- Extract relevant activities and record estimates of spatio-temporal footprints
- Quit SPIDA - any selections made will be lost!
2. Analysis of Complexity of Decommissioning in MPAs

### Categories used to record:

<table>
<thead>
<tr>
<th>Spatial extent</th>
<th>Duration</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local (0-1m)</td>
<td>Up to 1 day</td>
<td>One-off (single occurrence)</td>
</tr>
<tr>
<td>Restricted nearfield (1-10m)</td>
<td>Up to 1 week</td>
<td>Repeating: minute-by-minute</td>
</tr>
<tr>
<td>Nearfield (10-100m)</td>
<td>Up to 1 month</td>
<td>Repeating: hourly</td>
</tr>
<tr>
<td>Farfield (100m-1km)</td>
<td>Up to 2 weeks</td>
<td>Repeating: daily</td>
</tr>
<tr>
<td>Widespread (in excess of 1km)</td>
<td>Up to 2 months</td>
<td>More than 2 months</td>
</tr>
</tbody>
</table>

### Activity potentially giving rise to pressures

<table>
<thead>
<tr>
<th>Infrastructure type: Platform jackets</th>
<th>Spatial range of activity's impacts</th>
<th>Frequency of activity</th>
<th>Overall duration of activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decommissioning objective: Full removal</td>
<td>Nearfield (10-100m)</td>
<td>One-off (single occurrence)</td>
<td>Up to 1 week</td>
</tr>
<tr>
<td>Decommissioning method: Multiple lifts using a sheer-leg barge or smaller HLV</td>
<td>Farfield (100m-1km)</td>
<td>One-off (single occurrence)</td>
<td>Up to 1 week</td>
</tr>
<tr>
<td>Vessel movements</td>
<td>Nearfield (10-100m)</td>
<td>Repeating: daily</td>
<td>Up to 1 week</td>
</tr>
<tr>
<td>Overtrawl survey</td>
<td>Restricted nearfield (1-10m)</td>
<td>One-off (single occurrence)</td>
<td>Up to 1 week</td>
</tr>
<tr>
<td>Rig removal</td>
<td>Nearfield (10-100m)</td>
<td>Repeating: daily</td>
<td>Up to 1 week</td>
</tr>
<tr>
<td>Digging out infrastructure (excavation around jacket footings, pipeline sections, risers etc)</td>
<td>Restricted nearfield (1-10m)</td>
<td>Repeating: daily</td>
<td>Up to 1 week</td>
</tr>
<tr>
<td>Removal of the infrastructure (cutting / explosives)</td>
<td>Nearfield (10-100m)</td>
<td>Repeating: daily</td>
<td>Up to 1 week</td>
</tr>
<tr>
<td>Removal of the infrastructure (pipelines, jacket footings (non-deregression), risers, mattresses) (impact on seabed)</td>
<td>Nearfield (10-100m)</td>
<td>Repeating: daily</td>
<td>Up to 1 week</td>
</tr>
</tbody>
</table>

- Infrastructure type: Platform jackets
  - Decommissioning objective: Full removal
  - Decommissioning method: Multiple lifts using a sheer-leg barge or smaller HLV

- Spatial extent
  - Local (0-1m)
  - Restricted nearfield (1-10m)
  - Nearfield (10-100m)
  - Farfield (100m-1km)
  - Widespread (in excess of 1km)

- Duration
  - Up to 1 day
  - Up to 1 week
  - Up to 1 month
  - Up to 2 weeks
  - Up to 2 months
  - More than 2 months

- Frequency
  - One-off (single occurrence)
  - Repeating: minute-by-minute
  - Repeating: hourly
  - Repeating: daily
2. Analysis of Complexity of Decommissioning in MPAs

### SPIDA: Screening Potential Impacts of Decommissioning Activities

#### 3: Selection of conservation features (species/habitats) & sensitivity levels for subsequent reporting

<table>
<thead>
<tr>
<th>Sensitivity</th>
<th>Rank</th>
<th>SPIDA Sensitivity Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Missing</td>
<td>0</td>
<td>Missing, or not assessed</td>
</tr>
<tr>
<td>Not assessed</td>
<td>0</td>
<td>Not sensitive</td>
</tr>
<tr>
<td>NS</td>
<td>0</td>
<td>Not sensitive to low sensitivity, or low sensitivity</td>
</tr>
<tr>
<td>NS-L</td>
<td>1</td>
<td>Not sensitive to low sensitivity, or low sensitivity</td>
</tr>
<tr>
<td>L</td>
<td>2</td>
<td>Not sensitive to moderate sensitivity, low to high sensitivity, or not sensitive to high sensitivity</td>
</tr>
<tr>
<td>NS-M</td>
<td>3</td>
<td>Not sensitive to moderate sensitivity, low to high sensitivity, or not sensitive to high sensitivity</td>
</tr>
<tr>
<td>L-M</td>
<td>4</td>
<td>Not sensitive to moderate sensitivity, low to high sensitivity, or not sensitive to high sensitivity</td>
</tr>
<tr>
<td>L-H</td>
<td>5</td>
<td>Not sensitive to moderate sensitivity, low to high sensitivity, or not sensitive to high sensitivity</td>
</tr>
<tr>
<td>NS-H</td>
<td>6</td>
<td>Not sensitive to moderate sensitivity, low to high sensitivity, or not sensitive to high sensitivity</td>
</tr>
<tr>
<td>M</td>
<td>7</td>
<td>Moderate sensitivity, moderate to high sensitivity, or high sensitivity</td>
</tr>
<tr>
<td>M-H</td>
<td>8</td>
<td>Moderate sensitivity, moderate to high sensitivity, or high sensitivity</td>
</tr>
<tr>
<td>H</td>
<td>9</td>
<td>Moderate sensitivity, moderate to high sensitivity, or high sensitivity</td>
</tr>
</tbody>
</table>

Reporting criteria:

- Select feature for report: Sabellaria spinulosa reefs
- Select minimum sensitivity group for report: M, M-H, or H (moderate sensitivity, moderate to high sensitivity, or high sensitivity)

Select to:

- Close this tab and return to previous screen (activity intensity details)
- Click here to run SENSITIVITIES REPORT
- Click here to run ECOSYSTEM SERVICES report
### 2. Analysis of Complexity of Decommissioning in MPAs

**SPIDA: Screening Potential Impacts of Decommissioning Activities**  
Assessment of feature sensitivities

- **Infrastructure type**: Platform jackets  
- **Decommissioning objective**: Full removal  
- **Decommissioning method**: Multiple lifts using a shear-leg barge or smaller HLV  
- **Report focussed on**: *Sabellaria spinulosa* reefs  
- Sensitivity range cut-off for reporting: M, M-H, or H (moderate sensitivity, moderate to high sensitivity, or high sensitivity)

<table>
<thead>
<tr>
<th>Key pressure(s)</th>
<th>Sensitivity to pressure</th>
<th>Activities potentially giving rise to pressures</th>
<th>- Export judgements regarding Activity intensity -</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penetration and/or disturbance of the substratum below the surface</td>
<td>H</td>
<td>Digging out infrastructure (excavation around jacket footings, pipeline sections, risers etc)</td>
<td>Spatial range of activity impacts</td>
</tr>
<tr>
<td>Penetration and/or disturbance of the substratum below the surface</td>
<td>H</td>
<td>Rig removal</td>
<td>Frequency of activity</td>
</tr>
<tr>
<td>Penetration and/or disturbance of the substratum below the surface</td>
<td>H</td>
<td>Overflank survey</td>
<td>Overall duration of activity</td>
</tr>
<tr>
<td>Physical change (to another substratum type) - change in substrata</td>
<td>H</td>
<td>Removal of the infrastructure (pipelines, jacket footings (non-derogation), risers, mattresses) (impact on seabed)</td>
<td></td>
</tr>
<tr>
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<td>H</td>
<td>Removal of the infrastructure (cutting / explosives)</td>
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<tr>
<td>Smothering and sitation rate changes (heavy)</td>
<td>M</td>
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# 2. Analysis of Complexity of Decommissioning in MPAs

## SPIDA: Screening Potential Impacts of Decommissioning Activities

**Assessment of potential impacts on Ecosystem Service provision**

- **Infrastructure type:** Platform jackets
- **Decommissioning objective:** Full removal
- **Decommissioning method:** Multiple lifts using a sheer-leg barge or smaller HLV
- **Report focused on:** Sabellaria spinulosa reefs
- **Sensitivity range cut-off for reporting:** M, M-H, or H (moderate sensitivity, moderate to high sensitivity, or high sensitivity)

### Ecosystem service details

<table>
<thead>
<tr>
<th>Category</th>
<th>Type</th>
<th>Detail</th>
<th>Pressures potentially affecting feature</th>
<th>Sensitivity to feature</th>
<th>Activities potentially giving rise to pressures</th>
<th>Expert judgements regarding Activity intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermediate Services</td>
<td>Supporting services</td>
<td>Formation of species habitat</td>
<td>3 (3) Smothering and siltation rate changes (heavy)</td>
<td>M (rig removal)</td>
<td>Nearfield (10-160 Farfield (100-m-t) Widespread (in ex)</td>
<td>Repeating: minute Repeating: hourly Up to 1 week</td>
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<td>Formation of species habitat</td>
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<td>M (removal of the infrastructure) (pipelines, jacket footings (non-derogation), risers, manholes) impact on seabed</td>
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<td>One-off (single pc) Repeating: minute Repeating: hourly Up to 1 month</td>
</tr>
</tbody>
</table>
3. Challenges and Future Work

Marine Environmental Challenges from Oil & Gas Decommissioning

- Loss and gain of habitats, surfaces, ES and societal benefits;
- Value of removing structures with and without damage;
- Whole system energy and economic budgets;
- Whole cycle environmental footprints at near and far scales;
- How to ensure the protection of other uses and users;
- Relevant baseline/reference condition (with or without structures);
- Harmonised implementation of GEcS (WFD), GEnS (MSFD), FCS (HD).
3. Challenges and Future Work

**Future Work**

- Applying the framework to a range of industry-led scenarios to provide the proof of concept;

- Improving knowledge of the key elements of the framework e.g. the Activities-Pressures relationships;

- Developing a combined scoring system (‘Spatial-Temporal Footprint Index’) for assessing spatial extent, duration and frequency of each Activity; and

- Increasing understanding and quantification of the ecosystem service components to enable an assessment of trade-offs under different scenarios.
Acknowledgements

• NERC Oil & Gas Innovation Programme (Ref: NE/P016553/1) for the DECOM-MPA project.

• Project Partners: BEIS, Shell UK Ltd., JNCC, Natural England, University of Hull, Heriot Watt University, Hartley Anderson Ltd.

• Wide range of stakeholders who have engaged with and provided valuable feedback on both the framework presented here and the DECOM-MPA project.

Dr Daryl Burdon - D.Burdon@hull.ac.uk - @DarylBurdon
Pipeline Decommissioning:
Generating an evidence base for comparative assessments

Sally Rouse, Nichola Lacey, Marianna Chimienti, Peter Hayes & Tom Wilding

NERC Oil and Gas Innovation Programme
Optimising decommissioning of oil and gas pipelines with respect to the commercial fishing sector on the UK continental shelf.

North Sea Pipelines

- 2700 pipelines in the NS
- ~ 44,000 km in length
- Range of pipe types and sizes
- Different installation methods
- 2% Decommm’d so far
Pipeline Decommissioning: Potential options

Removal

Leave in situ
Without intervention

Leave in situ
With intervention

Comparative Assessment
Comparative Assessment: A Balance

- Safety
- Environment
- Society
- Cost
- Technical feasibility
Comparative Assessment: A Balance

Safety

Environment

Society

Cost

Technical feasibility
Fisheries Considerations

- Assessment of impacts to the commercial fishing industry
- Potential snagging hazards
- Access rights and commercial considerations

Vessel Monitoring System Data

- UK Vessels > 15 m
- Location ~ 2 hours
- Three gear types
- 2007-2015
Development Stages of Data Layers
Angle of interaction

- Angle of interaction influences risk of snag
- Indicates if vessels are avoiding or actively targeting
- Quantify effects of pipeline installation and/or removal on fishing behaviour
Angle of interception between fishing tracks and pipelines
Effect on the angle of interaction: fishing tracks aligning with the pipeline.

- No effect
- Installed - 2011

- Installed - 2012

- No effect
Incident data

- Marine Accident Investigation Board
- OGUK Fisher’s Compensation fund
- 1599 incidents relating to range of O&G activities and infrastructure
Incident cause

- DEBRIS: 25.6%
- UNKNOWN: 20.6%
- WIRES OR CABLES: 18%
- PIPELINES: 16.2%

Incident outcome

- £: 96.7%
- Injury: 1.45%
- Warning: 1.86%

Losses & Risk model
Environmental considerations

- Impacts on decommissioning strategy on marine environment
- Presence of species and habitats of conservation interest
- Repurpose structural integrity monitoring footage for ecological assessment
15 taxa identified interacting with pipeline including *Sabelleria* and *Virgularia*

Fish, anemones and hermit crabs frequently observed

Catalogue of CF/S on pipelines and matrices of sensitives to decom
# Sensitivity scores

<table>
<thead>
<tr>
<th>Pipeline Attribute</th>
<th>In situ interaction</th>
<th>Remove interaction</th>
<th>Rock dump interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Virgularia</td>
<td>Lophelia</td>
<td>Virgularia</td>
</tr>
<tr>
<td>Mud</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sand</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0-50 m</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>51-100 m</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>&gt; 100 m</td>
<td>0</td>
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<tr>
<td>SCORE</td>
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<td>0</td>
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</tbody>
</table>
Applications for Industry and Regulators

- Incorporation into decommissioning plans
- Risk-based integrity monitoring
- Management of snagging risk
- Balance fishing and environmental considerations
- Basis of a regional approach to decommissioning
Project Outputs

Published


Coming soon


- Chimienti, M., Rouse, S. & Hayes, P. (in prep) Fishing vessel behaviour around and oil and gas pipelines in the North Sea. *Marine Policy*


Data sets

Plug: NERC Innovative Monitoring

3D modelling of Marine Growth
Contact Details:
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tom.wilding@sams.ac.uk
peter.hayes@gov.scot
Autonomous marine environmental monitoring for decommissioning


* bjb@noc.ac.uk
Challenge: long-term environmental monitoring post-decommissioning.

Possible solution: various marine autonomous systems.

Starting point: currently available research & commercial systems.

Some key themes: spatial extent / temporal change
- Map infrastructure, cuttings, surrounding seafloor
- Visual assessment of infrastructure, cuttings, pipelines, biological communities
- Water quality assessment by sensors

Assessment:
- How could / would it work?
- How comparable would resultant data and interpretations be?
- What trades off are there to be made?
- Do the benefits outweigh the limitations (change / cost / fit for purpose)?

Output:
- Peer-reviewed review / opinion publication
- Open forum workshop
Autonomous Environmental monitoring for Decommissioning
One-day workshop

Venue: Board Room,
National Oceanography Centre,
European Way,
Southampton, SO14 3ZH

Date: 16th March 2018, 09:30 – 16:15

We can accommodate a few more stakeholders, if interested please contact Daniel Jones (dj1@noc.ac.uk) to check availability.
- Argo floats (× 4000 global ocean)
- Submarine gliders
- Autonomous underwater vehicles
- Unmanned surface vehicles
- Fixed-point observatories
- Seabed landing & crawling autonomous vehicles

Multibeam echosounder; Sidescan sonar; Synthetic aperture sonar; Sub-bottom profiler; Conventional photography; Laser-based particle / droplet / bubble imaging; Laser line scanning (laser striping, range-gated imaging, structured lighting, combine conventional imaging and 3D scene capture); Conductivity; Temperature; Depth; Oxygen; Turbidity, Fluorescence (Chl and CDOM); Membrane inlet mass spectrometry; Manganese ‘sniffer’; Acoustic Doppler current profiling; hydro- / bioacoustic, multifrequency / broadband, fisheries echosounder; Passive acoustic monitoring
Darwin Mounds
(1000 m water depth)
Special Area of Conservation
[NERC repeat survey site]

North West Rockall Bank
Special Area of Conservation
(250 m water depth)

Porcupine Abyssal Plain
Sustained Observatory
NERC long-term monitoring site (4850 m water depth)

Greater Haig Fras (HF)
Marine Conservation Zone
(100 m water depth)
[NERC repeat survey site]

NERC & Defra Shelf Sea
Biogeochemistry Programme
sites (A, G, H, I)
(100 m water depth)
How do you (afford to) monitor all of the UK’s MPAs every five years?

Are AUVs an option?
Greater Haig Fras
MCZ
seafloor habitats

(a) Hc
(b) Hs
(c) Ch
(d) Sh
(f) C
(g) S

Hard
Mixed
Coarse
Sand

noc.ac.uk
Greater Haig Fras MCZ faunal composition
NERC & Defra Shelf Sea Biogeochemistry Programme

(a) Similarity (%)
- Site G - Sand
- Site H - Muddy sand
- Site I - Muddy sand

(b) Number of species vs. Habitat heterogeneity [exp(H')]
- Site G
- Sest
- Site H
- exp(H')
- Site I
- 1/D
Mass imagery
Machine vision
A.I. data generation

Long-term monitoring
water column &
seafloor

Wake &
repeat

Park &
sleep

noc.ac.uk
(realistic) Post-decommissioning monitoring (in perpetuity)

- shifting baseline
- competing impacts
- broad-scale & multi-site approach (multi-purpose)
- autonomy may be the only viable option
Automated Marine Growth Analysis for Decommissioning

Dr Kate Gormley, University of Aberdeen
Project Background

• BMT Cordah Ltd. Have been undertaking marine growth assessments since the early 1980’s
• Industry challenges – access to data, data sharing, innovative monitoring, cost savings, efficiency
• Dr David Kline, Scripps Institute of Oceanography, San Diego
  • CoralNET Project - a web solution for coral reef analysis

“Global and local stressors have caused a rapid decline of coral reefs across the world. To monitor the changes and take appropriate action large spatio-temporal surveys are needed. Data collection speeds are typically sufficient to meet this need but the subsequent image analysis remains slow as manual inspection of each photo is required. This creates a ‘manual annotation bottleneck’”.

“CoralNet reduces this bottleneck by allowing modern computer vision algorithms to be deployed alongside human experts. Often 50-100% automation can be achieved with minimal reduction in the quality of the final data-product. CoralNet, by its nature, also provides a platform for collaboration & sharing of data”.
Project Summary

- Collected a number of images from North Sea operators
- A list of "labels" was created, based on our understanding of marine growth in the North Sea
- A total of 857 images were originally trained, confidence threshold set at 100%
- 20 annotation points per image, so a total of 17,140 points annotated
- Image quality varied, from excellent HD images to poor quality
- Over 1000 images collected, but a number discarded based on quality
- Following training of the software, three BP platforms were used for testing
Following training of the software, images for 3 BP test platforms were uploaded and tested using 3 different testing methods. Following analysis by the software:

- Percentage covers for each platform were exported (data analysed by software; unconfirmed)
- Annotation points were confirmed (if correct) or corrected (if incorrect)
- Corrected and confirmed percentage covers for each platform were exported (confirmed)
- Repeated for each testing method (as per table)
- All 3 platforms analysed by independent analyst by eye

### Testing Method

<table>
<thead>
<tr>
<th>Testing Method</th>
<th>Name</th>
<th>Confidence Threshold</th>
<th>Annotation Point Generation</th>
<th>No. of Images</th>
<th>No. Images in Classifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Platform 1A</td>
<td>80%</td>
<td>• Image annotation area: X: 10 - 95% / Y: 10 - 95%</td>
<td>73</td>
<td>857</td>
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<tr>
<td></td>
<td>Platform 2A</td>
<td>90%</td>
<td>• 20 random points</td>
<td>95</td>
<td>930</td>
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<tr>
<td></td>
<td>Platform 3A</td>
<td>80%</td>
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<td>1322</td>
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<tr>
<td>B</td>
<td>Platform 1B</td>
<td>90%</td>
<td>• Image annotation area: X: 10 - 95% / Y: 10 - 95%</td>
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<td>1025</td>
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<tr>
<td></td>
<td>Platform 2B</td>
<td>90%</td>
<td>• Stratified random¹, 5 rows x 5 columns of cells, 2 points per cell (total of 50 points)</td>
<td>95</td>
<td>1025 and 1142*</td>
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<tr>
<td></td>
<td>Platform 3B</td>
<td>90%</td>
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<td>1193</td>
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<tr>
<td>C</td>
<td>Platform 3C</td>
<td>90%</td>
<td>• Image annotation area: X: 15 – 90% / Y: 15 – 90%</td>
<td>66</td>
<td>1261</td>
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</tbody>
</table>
Results
Platform 1A

Unconfirmed

Confirmed

Eye
Platform 1B

Unconfirmed

Confirmed

Eye
Platform 2A

Unconfirmed

Confirmed

Eye
Platform 3C

Unconfirmed

Confirmed

Eye
Results

• Biodiversity – Shannon-Wiener Index
  • Platform 1 – overall LOW diversity, highest diversity at 30 to 40m depth
  • Platform 2 – overall LOW diversity, highest diversity (moderate) at 50 to 60 m depth
  • Platform 3 – overall MODERATE diversity, highest diversity at 150 to 160 m depth
    • Note: not all depth ranges were analysed on platform 3 due to lack of images

• Comparisons
  • No significant difference between testing methods
Limitations

• No. of annotation points didn’t seem to have a significant impact of the output on less diverse platforms

• Software only records annotation points, does not extrapolate up across the whole image (therefore, may miss some species)
  • Also, only up to 100% - does not take layering of species into account

• No. images trained did not have significant variety, therefore when tested on platforms with higher diversity, the confidence of the software was lower

• “No data” was not recorded when analysed by eye, therefore has an overall influence on the significant difference

• Quality of images heavily influenced the training and testing classifier

• *Metridium dianthus* and “no data” were the highest number species trained, therefore highest confidence in testing image sets – need more variety of images and species

• At present, no means of making training data available to other projects – this is something CoralNet are currently working on…. Watch this space!
Recommendations to Industry

• When collecting new survey footage, the use of a high definition (HD) video or camera is preferred.
• If using video only, allow time for the ROV to settle at various points on the platform jacket.
• Settle at different locations within 10 m depth ranges, at different orientations and perpendicular to the structure.
• Stay within 1 m of the structure and try to fill the frame with the structure in order to limit “off-structure” areas within images.
• Allow for a minimum of 10 images to be collected from each 10 m depth range.
• Use scale bars or scale lasers as accurate pixel size estimation is critical to the accuracy of the automated system. Ensure that the scale bar is not intrusive to the footage/image and ensure ROV arms or cathodic protection (CP) probes are not within the shot.
• Remove overlay text from survey footage, except for depth; or provide depth details in metadata or image title.
• Where text overlay is removed, the image boundary within CoralNet can be set to X: 10 - 95% / Y: 10 - 95%. Where the text overlay is present, it may be necessary to test the boundary to minimise the chance of points landing on the text.
• It is recommended that 50 annotation points per image should be used, however, this will be dependent on the image quality, the number of rare species of interest and the total number of images taken per depth. This should be considered on a platform by platform basis.
• The annotation point distribution should be set within a grid – either uniform or stratified random (as defined by CoralNet) to ensure no overlap of points and equal coverage of the image.
• Where it is not possible to use images with no “no data”, following analysis, normalise the dataset to remove “no data”
Thank you for your time

Acknowledgements:
Faron McLellan, BMT Cordah Ltd.
Dr Joe Ferris, ECAP Consultancy Group/BMT Cordah Ltd.
Chris McCabe and Claire Hinton, BMT Cordah Ltd.
Dr Beth Scott, University of Aberdeen
Melanie Netherway and Don Orr, BP UK
Calum Raey, Bibby Offshore
George Gair, i-Tech 7/Subsea 7
Alan Buchan, Wood Group Kenny

Paper: Gormley et al., Automated Image Analysis of Offshore Infrastructure Marine Biofouling, 2018
Journal of Marine Science and Engineering 6 (2) http://www.mdpi.com/2077-1312/6/1/2/pdf
Future funding opportunities

Sarah Keynes
NERC Senior Programme Manager (Innovation)
saryne@nerc.ac.uk

Mamiko Ohno
EPSRC Senior Portfolio Manager
Mamiko.ohno@epsrc.ac.uk
Existing environmental science and research → Real issues and opportunities facing end-users → Innovative approaches, solutions and tools
IPOG
Call themes

Funding theme 1: Decommissioning

Theme 2: Innovative monitoring approaches (RAS, sensors etc.)

Theme 3: Environmental data (management, sharing, access, collaboration)

Data call launch late 2018 £2m investment

CHALLENGE AREAS

Decommissioning – Environmental Management
Extending the life of mature basins
Challenging environments
Unconventional hydrocarbons
NERC Innovation
Open mechanisms

KE Fellowships
Open and directed calls

Innovation Project calls
Open and directed calls

Regional Impact from Science of the Environment

Innovation Placements
Open and directed calls

Commercialisation Pathfinder & Follow on Fund
Environmental Data Service
A step change in data innovation

**Tools and Services**
- Development of common processes and procedures
- Analytical and technical tools
- Data Centre Expertise

**Operational Service**
- Facilitation and brokerage to support external data consumers
- Capturing user feedback
- Producing impact reports
- Coordination of call for ideas process

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**‘Technical Integration’**
- Data availability
- Data inter-operability
- Data usage
- Integration of NERC data with that from other data holders, users or sources to produce new and commercially valuable hybrid data products

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**Data Innovation Portal**
- Data discoverability
- User registration data
- User feedback

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£10m investment
Challenge-led innovation
Business focused
Current and Future Calls

Current Calls

- 2018 CDT call
- Nuclear Consortia Follow-on Funding
- International centre-to-centre research collaborations
- EPSRC fellowships

Future Calls

- Industrial Strategy Challenge Fund
- Strategic Priorities Fund
Key points on the CDT call

- Call opened 17 January; two-stage process; outlines deadline 13 March 2018; full proposal deadline 31 July 2018; funding decisions December 2018; new cohort starts 2019/20 academic year.
- The budget will be up to £492M to support around 90-120 Centres for Doctoral Training.
- Each CDT must support a minimum of 50 students, over five cohorts; 20-40% of the studentship costs must come from a non-RCUK source.
- There are two stream for applications – a priority area stream and an open stream.
- Length of studentship is 4 years.
- [https://www.epsrc.ac.uk/skills/students/centres/2018-cdt-exercise/](https://www.epsrc.ac.uk/skills/students/centres/2018-cdt-exercise/)
Energy Priority Areas

- RENEWABLE ENERGY
- NUCLEAR FISSION AND FUSION FOR ENERGY
- ENERGY RESILIENCE THROUGH SECURITY, INTEGRATION, DEMAND MANAGEMENT AND DECARBONISATION
- ENERGY STORAGE AND CONVERSION

NERC are committing £2.2M towards Renewable Energy
CDTs in this area should:

- address a broader set of challenges, taking account of economic, societal, consumer and environmental values
- inform policy and regulatory frameworks to better support renewables
- take a cross-disciplinary, whole-systems approach to break down silos
- develop links with a diverse range of industrial sectors in order to encourage cross-sector learning
EPSRC Fellowships

- Support for three stages:
  - Postdoctoral
  - Early Career
  - Established Career

- Applications welcome at any time, with two rounds of interviews typically held each year

- Applicants work with their institutions to establish which career stage suits them best

- David Clarke Fellowship available for Postdoctoral fellowships (co-funded by ETI)
## Energy Fellowship Areas

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<th>Post-doctoral Fellowships</th>
<th>Early career Fellowships</th>
<th>Established career Fellowships</th>
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