Decommissioning of Steel Piled Jackets in the North Sea Region

November 2017

Acknowledgments

Oil & Gas UK would like to thank the following organisations for their support during the preparation of this document: BP, Canadian Natural Resources International, Shell UK, ConocoPhillips and The International Association of Oil and Gas Producers (IOGP).

ISBN: 1 903 004 97 7

PUBLISHED BY OIL & GAS UK

London Office:

6th Floor East, Portland House, Bressenden Place, London, SW1E 5BH
Tel: 020 7802 2400 Fax: 020 7802 2401

Aberdeen Office:

Exchange 2, 3rd Floor, 62 Market Street, Aberdeen, AB11 5PJ
Tel: 01224 577250 Fax: 01224 577251

info@oilandgasuk.co.uk

www.oilandgasuk.co.uk

Decommissioning of Steel Piled Jackets in the North Sea Region

November 2017

Contents

Table of Figures

Table of Tables

List of Abbreviations

Abbreviations	Definitions
BEIS	Department of Business, Energy and Industrial Strategy
BTA	Buoyancy Tank Assembly
EIA	Environmental Impact Assessment
EEMS	Environmental and Emissions Monitoring System
HLV	Heavy Lift Vessel
HSE	Health and Safety Executive
IMO	International Maritime Organisation
IOGP	The International Association of Oil & Gas Producers
LAT	Lowest Astronomical Tide
MPA	Marine Protected Area
MSF	Module Support Frame
NNS	Northern North Sea
NORM	Naturally Occurring Radioactive Material
NPD	Norwegian Petroleum Directorate
OGA	Oil and Gas Authority
OPRED	Offshore Petroleum Regulator for the Environment and Decommissioning
OSPAR	Oslo and Paris Convention
PDO	Plan for Development and Operation
ROV	Remotely Operated Vehicle
SFF	Scottish Fishermen's Federation
SNS	Southern North Sea
SPJ	Steel Piled Jacket
SSCV	Semi-submersible Crane Vessel
UKCS	UK Continental Shelf
UNCLOS	United Nations Convention on the Law of the Sea
WBS	Work Breakdown Structure

Definitions

Term	Definitions
Derogation	Deviation from a rule. In the context of this document it refers to deviation from Paragraph 2 of the OSPAR Decision 98/3 on the Disposal of Disused Offshore Installations. This prohibits the dumping at sea or leaving wholly, or partly in place, a disused offshore installation.
Drilling Template	A steel structure installed on the seabed through which production wells are drilled. A template is often used to allow pre-drilling of wells before a fixed or floating facility is installed above or over it.
Footings	As defined in OSPAR Decision 98/3: "Those parts of a steel installation which: (i) are below the highest point of the piles which connect the installation to the seabed (ii) in the case of an installation built without piling, form the foundation of the installation and contain amounts of cement grouting similar to those found in footings as defined in Annex 1 of OSPAR Decision 98/3 (iii) are so closely connected to the parts mentioned in (i) and (ii) above as to present major engineering problems in severing them from those parts."
Steel Piled Jacket	The substructure of a steel offshore platform that supports the topsides. It includes the steelwork associated with the footings.
Topsides	Those parts of an offshore installation, which are not part of the substructure. It includes modular support frames and decks where their removal would not endanger the structural stability of the substructure

1 Summary

Since 1969 a total of 625 steel piled jackets (or SPJ) have been installed in the North Sea Region, including the UK, Norway, Netherlands and Denmark. The size and configuration of these structures varies greatly from monopod wellhead platforms in the southern North Sea weighing several hundred tonnes, to the largest eight-legged integrated platforms in the northern North Sea weighing in excess of 20,000 tonnes at installation.

Under current regulations, with the exception of the largest and oldest of these structures, they will all be removed and recovered to shore for disposal as part of an approved decommissioning programme. To-date 63 steel platforms have been decommissioned in the North Sea; all except two have had their piles cut below the seabed and removed to shore for disposal. The two exceptions are BP's Northwest Hutton and CNRI's Murchison platforms, the owners of which were granted derogation to leave the footings of the structures in place at decommissioning.

The principal regulation determining the fate of steel structures at decommissioning is OSPAR Decision 98/3[1] on the Disposal of Disused Offshore Installations, which states: "the dumping, and the leaving wholly or partly in place, of disused offshore installations within the maritime area is prohibited". This requires all steel structures to be removed at decommissioning, unless the jacket weighed in excess of 10,000 tonnes at installation and was installed before the Decision came into effect in February 1999. Of the 552 SPJs remaining, 35 meet these criteria and hence their owners may apply for a derogation to leave their footings in place at decommissioning.

Other potential options exist for decommissioning steel structures such as decommissioning the whole structure and leaving it in place, or moving the structure to form an artificial reef as in the Gulf of Mexico. Such options are not presently available in the OSPAR region.

The regulatory framework and the process of decommissioning are well established in the UK, Norway and other countries surrounding the North Sea. In the UK, a licensee's proposal for performing a decommissioning project is approved by the regulator (OPRED, BEIS[2]), following extensive stakeholder engagement. A similar process applies in Norway. Where derogation from Decision 98/3 is sought, the owner must demonstrate that the option selected is based on a balanced view of safety, environmental and societal impact, technical feasibility and economics.

The technical solutions available for removing all or part of steel structures are determined by the available technology and in particular, available cutting and lifting solutions. Both these areas have seen significant developments over the past five years. The Murchison project in 2017 saw the successful cut of a 6 metre diameter jacket leg using a remotely operated, diamond wire cutting tool, the largest such cut performed subsea. Similarly, new lifting vessels and techniques have emerged with the lift vessel *Pioneering Spirit* entering service in 2016, although its owners Allseas have stated that it will not be equipped to lift steel piled jackets until 2019.

[1] OSPAR Decision 98/3 on the Disposal of Disused Offshore Installations, Ministerial Meeting of the OSPAR Commission, Sintra, 22 to 23 July 1998.

[2] Offshore Petroleum Regulator for the Environment and Decommissioning within the Department of Business, Energy and Industrial Strategy.

Despite these technological developments, the cutting of pile clusters of the largest platforms at, or several metres below the seabed (as required under regulations), remains beyond the limits of current tooling. Given the prevailing limitations on cutting technology, the criteria within current regulations that define the circumstances in which licensees may apply to leave these sections in place at decommissioning remain appropriate.

2 Introduction

Steel structures, fixed to the seabed using piles, have been the primary method of installing oil and gas production facilities in the North Sea since 1969, when West Sole 'A' was the first 'steel piled jacket' (or SPJ) installed in the basin. Since then, in excess of 600 steel platforms have been installed in the North Sea Region.

This report provides a description and inventory of the SPJs in the region and describes the process of decommissioning and how the fate of these structures is determined. Decommissioning of SPJs varies depending on type and construction. Much attention is given to ensure the best technical solution is selected for each installation and where options are available, decisions are based on a balanced consideration of safety, environmental and societal impact and economics.

Current regulations require offshore installations to be removed at the end of their useful life. The options available to owners are determined mainly by the available technology and this report highlights current capability limits for cutting and lifting steel jackets and recovering them to shore. The focus of the document is on the fate of steel substructures at decommissioning, assuming in all cases that the topsides has been removed to shore for disposal, as is required by OSPAR Decision 98/3.

This document is an update of the first *Decommissioning of Steel Piled Jackets in the North Sea Region*[3] report published by Oil & Gas UK in 2012 and complements a similar document prepared by IOGP on Concrete Gravity Based Structures[4].

---

[3] Decommissioning of Steel Piled Jackets in the North Sea Region. Oil & Gas UK Report OP074, October 2012

[4] Decommissioning of Offshore Concrete Gravity Based Structures in the OSPAR Maritime Area / Other Global Regions. IOGP Report No. 484, November 2012.

3 Steel Piled Jackets in the North Sea Region

A total of 625 SPJs have been installed in the North Sea Region, including the Irish Sea and West of Shetlands. Variations in regional conditions, for example water depth and environmental loadings and different production and processing needs, have led to a variety of SPJs being installed as shown in Figure 1.

Figure 1 Examples of Steel Piled Jackets in the North Sea Region

3.1 Self-Floaters

These are the largest of the steel jackets installed in the North Sea and typically weigh between 12,000 to 43,000 tonnes. Their key feature is that typically, two of the jacket's eight legs are up to 10 metres in diameter and provided buoyancy during installation. These jackets were built in a fabrication yard, floated horizontally to the location using their own inherent buoyancy, and upended through controlled flooding of the jacket members. Cranes were sometimes required to assist with final positioning.

There are eight steel piled jackets in the North Sea Region installed as 'self-floaters' and none has yet been decommissioned. The Brent A jacket will likely be the first self-floater to be decommissioned in the North Sea as part of the on-going Shell Brent Decommissioning Project.

3.2 Barge-Launched

Barge-launched jackets typically weigh up to 25,000 tonnes. The jackets are made in a fabrication yard and transported horizontally to the location via barge. The barge then launches the jacket over rocker beams and is upended through controlled flooding. These, too, can require crane assistance for final positioning.

There have been 68 barge-launched jackets installed in the North Sea Region, with 17 decommissioned to date. All barge-launched jackets installed after OSPAR 98/3 came into effect are required to be removed after decommissioning. Jackets installed since OSPAR 98/3 came into effect include Statoil's Mariner platform and BP's Clair Ridge DP platform. The Mariner SPJ, which was installed in 2015 and weighs 22,400 tonnes, is one of the largest barge-launched jackets installed in the North Sea.

3.3 Lift-Installed

Lift-installed jackets weigh less than 10,000 tonnes and are also yard-fabricated. They are transported horizontally by barge to the location, where they are lifted from the barge into position by a crane vessel.

There have been 103 jackets installed in the North Sea using this method. Thus far, Ekofisk W, Frigg QP, and Frøy have been decommissioned. They became a popular method of installation after 1990 when the industry started to cut costs in response to CRINE[5], which lead to smaller and lighter platforms being commissioned.

3.4 Shallow Water

Shallow water jackets usually weigh less than 2,000 tonnes and are deployed in water depths of 55 metres or less. They are either barge-launched or lift-installed, and include minimum facilities platforms such as monotowers.

To date, 444 of these jackets have been installed in the North Sea, predominantly in the Netherlands and southern sector of the UK Continental Shelf. Forty-three shallow water jackets have been decommissioned to date.

3.5 Inventory

Of the 625 steel-piled jackets installed in the North Sea Region, 63 have been decommissioned.

Table 1 gives the estimated numbers for each jacket category in the North Sea, broken down by region. Those decommissioned to date are also included. Of those jackets yet to be decommissioned, 35 meet

[5] CRINE or *Cost Reduction in the New Era* was the UK industry's response to the low oil prices in the late 1980s. By increasing collaboration between operators and contractors, the industry sought to reduce development costs by 30 per cent and increase the UK's competitiveness in the global oil and gas market.

the criteria for potentially seeking derogation under OSPAR Decision 98/3. Two of these, Miller and Brent Alpha, have already ceased production. Decommissioning is underway at Miller.

Table 1 Steel Piled Jackets in the North Sea Region (2017)

	Countries					Totals	Decommissioned to-date
	UK	Norway	Netherlands	Denmark	Other		
Self-Floater[1]	8 (8)	0	0	0	0	**8**	**0**
Barge-Launched[1]	28 (21)	38 (7)	0	0	2	**68**	**17(2)[2]**
Lift-Installed	52	41 (1)	0	10	0	**103**	**3**
Shallow Water	216	2	177	48	3	**446**	**43**
Totals	**304 (29)**	**81 (8)**	**177**	**58**	**5**	**625**	**63 (2)**

[1] Numbers in brackets indicates number of SPJs that meet the criteria for possible derogation under OSPAR Decision 98/3.

[2] Northwest Hutton and Murchison have been decommissioned; BP has been granted derogation to leave the footings of the Miller platform in-place at decommissioning.

4 Decommissioning Regulations in the North Sea Region

The first international conference on national rights and obligations relating to the marine environment took place in Geneva in 1958 and resulted in the Geneva Convention which came into force in 1964. This agreement initiated the requirements to regulate offshore installations and specifically states that disused structures should be removed.

The United Nations Convention on the Law of the Sea (UNCLOS) superseded this agreement in most countries in 1982. This extensive agreement covers many aspects of national stewardship of the marine environment, including environmental and pollution control responsibilities. It contains particular reference to the permitting requirements for leaving man-made structures in the marine environment.

In 1989, the International Maritime Organisation's (IMO) Guidelines and Standards for the Removal of Offshore Installations and Structures on the Continental Shelf and in the Exclusive Economic Zone were adopted by countries in the North Sea Region. Developed from Article 60 of UNCLOS, the guidelines specifically cover disused offshore installations and the factors that need to be considered when granting permission for a structure, or part of a structure, to be left in place.

Regarding SPJs, the IMO Guidelines state that any structure protruding the sea should be maintained to prevent structural failure and, if a structure is partially removed, an unobstructed water column of not less than 55m should be maintained.

These guidelines also advise that all structures in a water depth of 75 metres or less and weighing under 4,000 tonnes, excluding topsides and decks, should be removed. For structures installed after 1 January 1998, the guidance water depth for complete removal was increased to 100 metres.

The London Convention 1972 and, notably, the 1996 Protocol effectively banned all dumping at sea except for a list of wastes for which a permit may be sought from the host state. Man-made structures are included on this list in Annex 1 of the 1996 agreement. This requires that re-use or recycling be considered ahead of dumping, with the emphasis on minimising the impact on the environment.

Regulations on the decommissioning of offshore structures were consolidated and reinforced in 1998 when the OSPAR Contracting Partners agreed what was to become the OSPAR Decision 98/3 on the Disposal of Disused Offshore Installations[6].

OSPAR began in 1972 with the Oslo Convention and operates under the UNCLOS. It focuses on environmental policy to prevent marine pollution and achieve sustainable management of the North-East Atlantic marine ecosystem.

Decision 98/3 was an outcome of the OSPAR Environment Ministers Conference held in Sintra, Portugal, in July 1998. It prohibits the dumping in whole, or in part, of a disused offshore installation in the maritime area. It does, however, allow the appropriate regulatory authority, under certain circumstances, to consider granting a derogation to leave all, or part, of a structure in place.

[6] OSPAR Decision 98/3 on the Disposal of Disused Offshore Installations, Ministerial Meeting of the OSPAR Commission, Sintra, 22 to 23 July 1998.

The categories of installations that may seek derogation under OSPAR Decision 98/3 are defined as:

1. Steel structures weighing more than 10,000 tonnes in air and which were installed before February 1999. Derogations may be granted for all, or part, of the footings

2. Gravity-based concrete installations

3. Any other disused offshore structure, which has suffered unforeseen structural damage or deterioration to an extent that its removal represents equivalent difficulties.

Prior to granting derogation, and as part of its consultation process, the host state must submit notification to the OSPAR Executive and Contracting Parties who may provide comment.

Decision 98/3 came into force in February 1999 and is administered for example in the UK by the Offshore Petroleum Regulator for the Environment and Decommissioning within the Department for Business Energy and Industrial Strategy (OPRED-BEIS) and in Norway by the Norwegian Ministry of Petroleum and Energy (MPE). Under the terms of the Decision, Contracting Parties[7] agreed to review the categories in the Decision every five years, with the objective of reducing the scope of possible derogations under paragraph 3 of the Decision. There have been three reviews since the decision was implemented in February 1999, with no resulting change to the categories.

In the UK, a licence holder is required to submit a decommissioning programme, which will include SPJ decommissioning, for stakeholder consultation and regulator approval before carrying out any decommissioning works. Similar processes are required in Denmark, the Netherlands and Norway[8].

[7] Contracting Parties are the 15 state signatories to the OSPAR Convention, plus the European Union.

[8] Overview of International Offshore Decommissioning Regulations, Volume 1 – Facilities. IOGP Report 584, July 2017.

5 Decommissioning Options for Steel Piled Jackets

5.1 North Sea Decommissioning Options

The options available for decommissioning disused SPJs in the North Sea Region under OSPAR Decision 98/3 are described below, along with examples of other methods that have been used in different regions around the world.

5.1.1 Jacket Removed to Seabed and Transported to Shore

This is the base case for all SPJs weighing less than 10,000 tonnes. It involves cutting the piles that attach the jacket to the seabed and taking the complete structure to shore. This can be achieved in a number of ways depending on the size and complexity of the jacket.

For smaller shallow water jackets (described in Section 3.4), this typically involves cutting the piles (internally or externally) below the seabed and removing the structure with a single lift, using an appropriate lift vessel. It is then transported to shore either on the crane hook, the deck of the vessel or using a transport barge.

For larger structures, such as the barge-launched or lift-installed jackets, it is usually necessary to cut the jacket into smaller pieces and remove these individually onto the deck of a HLV or attendant barge.

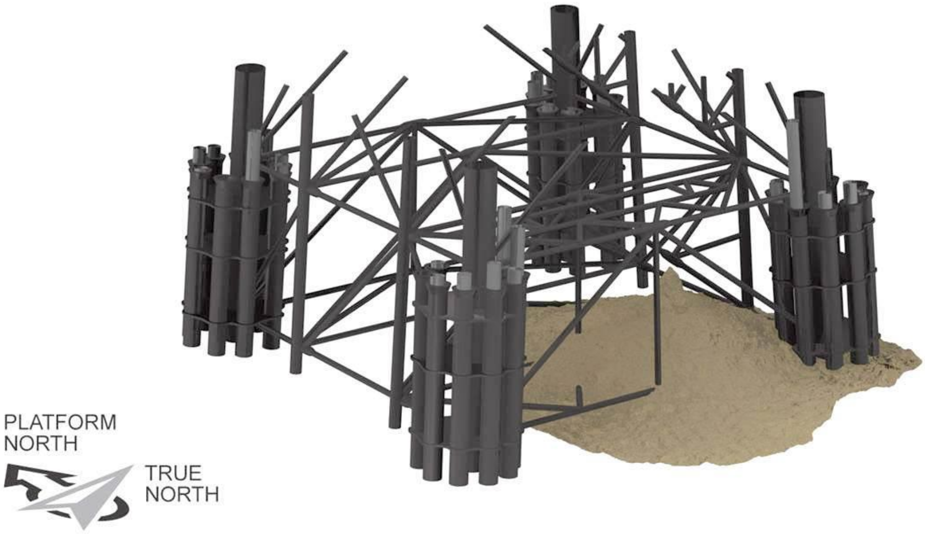
There have been numerous shallow water jackets removed in their entirety using heavy lift vessels, for example Welland, Esmond, Gordon, four of the Viking 'A' platform jackets and six jackets from Shell's Inde Field. Larger steel structures that have been removed completely include the Frigg QP, DP1 and DP2 jacket structures.

5.1.2 Remove to Footings

This scenario is permitted under OSPAR Decision 98/3, subject to a derogation being granted by the regulatory authority of the country in which the structure lies. It is only considered for SPJ structures installed prior to 1999 (when the decision came into force) and that weighed in excess of 10,000 tonnes at installation, although in practice this criterion is taken to include piles and grout, which also need to be considered at decommissioning, as they are an integral part of the structure.

Under this scenario, the jacket is removed down to the top of the footings. Footings can generally be described as those parts of a steel installation, which are below the highest point of the piles that connect the installation to the seabed. They are also deemed to include any associated structure(s) that are inherently part of the same technical challenge to remove. Figure 2 shows the footings of the Murchison jacket that were left in place at decommissioning after CNRI and their partners were granted a derogation under Decision 98/3.

Figure 2: Footings of a Large Steel Piled Jacket



Source: CNR International

The sizes of the sections removed under this scenario are determined by the overall structure configuration, the available offshore and onshore lift capacity, and the size and accessibility of the members to be cut underwater. The removal options are the same as those for full jacket removal and are driven by cutting and lifting capability. The jacket section(s) is transferred to shore by barge or on the deck of the lift vessel.

5.2 Selection of a Decommissioning Option

For structures that do not meet the category for possible derogation, the only option available under the regulations is full removal and hence no justification needs to be made by the operator for selecting that option.

Under OSPAR Decision 98/3[9], a request for derogation to leave footings in place must be made to the regulating authority, (i.e. OPRED in the UK), who is required to consult with the other OSPAR contracting parties before approving such applications. The application must be supported by a comprehensive *comparative assessment*, which considers the safety, environmental and societal impacts, technical feasibility and economic aspects of all options for disposal, such as reuse, recycling, disposal onshore and any other onshore disposal options. The regulator must in turn consult with statutory consultees and all other OSPAR Contracting Parties prior to granting derogation under Decision 98/3. To date, three derogations from OSPAR 98/3 for steel piled jackets have been permitted for operators to leave their footings in place at decommissioning: BP for Northwest Hutton, CNRI for Murchison and BP for Miller.

[9] OSPAR Decision 98/3 on the Disposal of Disused Offshore Installations, Ministerial Meeting of the OSPAR Commission, Sintra, 22 to 23 July 1998.

5.3 Other Decommissioning Options

Although the methods described below are not permitted in the OSPAR Region, they are outlined for information and completeness and, in some cases, have been used for decommissioning SPJs in other regions.

5.3.1 Decommission *In-situ*

Leaving an installation in place means decommissioning it *in situ* anchored to the seabed, without any significant deconstruction. In such a scenario, it is likely that the topsides would be removed and disposed of onshore, and installation and maintenance of navigational aids will be required as long as the SPJ structure remains a potential hazard to other users of the sea.

5.3.2 Topple *In Situ* as Artificial Reef

This scenario involves removing the topsides and cutting the legs of the jacket, and either pulling the structure over onto the seabed, or lifting and placing it next to any remaining jacket sections. In any scenario, IMO guidelines (see Section 4) require 55m clearance below the sea surface.

In 2009, Offshore Iwaki Oil Company adopted this method to decommission the Iwaki Platform offshore Japan[10]. It was also used for the damaged Baram 8 platform in Malaysia in 2004, which is now known as the Kenyalang Reef and used as a recreational dive site[11].

Following the tragic Piper Alpha disaster in the UK Continental Shelf of 6 July 1988, in which 167 people lost their lives, the unstable remains of the structure were authorised to be toppled as the safest and most respectful way of lowering the damaged structure to the seabed. This is the only example of 'toppling *in situ*' in the North Sea.

5.3.3 Remove to Seabed and Transport to Artificial Reef Site

This scenario is the same as that described above, except that the structure is taken to a designated reef site where it is deposited with similar structures. Such arrangements have been adopted for the disposal of disused offshore platforms in the USA, (for example as permitted in the Gulf of Mexico and California). No such option exists in the North Sea.

5.3.4 Remove to 55m Below LAT

For this scenario, the jacket legs and bracing members are removed to a depth of 55m below the lowest astronomical tide (to comply with IMO guidelines). The removed portion is then disposed of in an appropriate way. Options for section removal are the same as for removing the jacket structure down to the footings (see Section 5.1.2).

[10] See: http://sapuraacergy.com/wp-content/uploads/Iwaki-Platform-Decommissioning-Project-Japan.pdf.

[11] See: http://www.mssa.org.my/site/index.php?option=com_content&view=article&id=147&Itemid=209).

6 Decommissioning in the North Sea

6.1 Projects To Date

Of the 63 SPJs decommissioned to date in the North Sea, 44 were decommissioned from the UK Continental Shelf and the Netherlands. The majority of SPJs decommissioned have been shallow water jackets with weights ranging from 120 to 2,300 tonnes.

In Norway, 18 SPJs have been decommissioned to date, the majority of which were installed using the barge-launch method with a weight range of 760 to 11,200 tonnes.

The largest SPJ decommissioned to date in the North Sea is the Murchison barge-launched jacket that weighed over 24,600 tonnes at installation in 1980 (see Murchison Case Study).

6.2 UK Continental Shelf

The majority of decommissioning activity on the UK Continental Shelf (UKCS) has been concentrated in the southern North Sea, with 18 of the 22 SPJs removed in the UK sector coming from this region. This has led to the development of a robust supply chain for decommissioning services along the east coast of the UK and the Netherlands.

A small number of large SPJs (i.e. greater than 10,000 tonnes in weight) have been decommissioned from the northern North Sea. In 2009, BP was granted derogation to leave the footings in place of the 17,500 tonne North West Hutton barge-launched jacket. The jacket was decommissioned using the piece-small approach involving 58 lifts, with 248 cuts to jacket members[12].

In 2017, Murchison jacket was removed to the footings following a derogation being granted to leave the footings in place. The jacket, which weighed 24,600 tonnes (excluding piles) at installation, was removed to the footings using the piece-large (reverse installation) method. The removal campaign comprised of four heavy lifts and 79 tubular cuts (see Murchison Case Study).

6.3 Norwegian North Sea

There have been 18 SPJs decommissioned in the Norwegian North Sea to date, with ten of the platforms removed to date forming a single campaign performed by ConocoPhillips at Ekofisk between 2008 and 2014. The EKOD (2/4D) drilling, production, and accommodation platform formed part of this campaign. With a weight of close to 3,300 tonnes, the jacket was cut in two parts horizontally and transported to shore on a heavy lift vessel; the upper section on the deck and the lower part carried on the crane hooks.

The removal method used for 2/4D was similar to that used on the other jackets within the campaign and the same method is being applied to ConocoPhillips current removal campaign (See West Ekofisk, EKOD (2/4D) Case Study)

---

[12] North West Hutton Project Summary, GOM 3rd Annual Decommissioning and Abandonment Summit, Houston 15-16 March 2011.

7 Safety

7.1 Overview

Safety is paramount and an integral part of the planning and management of all phases of a decommissioning project. Whether planning the removal of a shallow-water jacket in the southern North Sea or a jacket originally weighing in excess of 10,000 tonne in the northern North Sea, safety forms a key part of determining the most appropriate method for decommissioning.

On the UK Continental Shelf (UKCS), before any decommissioning work can begin on a facility, the *Safety Case* for the installation must be updated. Decommissioning involves different activities from the day-to-day operation of a platform and so new and different hazards need to be managed. The updated *Safety Case* is submitted to the Health and Safety Executive (HSE) for assessment. In Norway, the requirement is for operators to prepare a "Plan for Development and Operation" (PDO) of a petroleum deposit.

The process of decommissioning is distinct from construction and operations, and has its own specific challenges. The key safety aspects of a decommissioning project are highlighted below.

7.2 Health and Safety Challenges

The main health and safety challenges that may pose a risk to personnel are common to all decommissioning options and jacket removal and disposal methods, albeit the scale of the risk may vary. The areas of concern are as follows:

- **Lifting** – the large number of lifts and the uncertainties surrounding load paths and structural integrity
- **Diving** – significant diver intervention may be required to support extensive subsea cutting and lifting operations
- **Hazardous substances** – legacy materials of construction and operations, as well as products released during decommissioning activity, such as from hot work during dismantling
- **Integrity** – hidden flaws and structural degradation in aged facilities
- **Changing work environment** – worksite configuration and safety procedures constantly change as work progresses, with limited opportunity to learn lessons
- **High levels of manual activity** – high numbers of personnel can be involved at all stages of the project, onshore and offshore, performing extensively manual tasks
- **Working at height** – for offshore and onshore personnel, including the risk of dropped objects, which may include extensive marine growth and loose items embedded within marine growth
- **Dynamic Organisational Structure** – organisational changes, dynamic manning levels, skill retention issues
- **Poor weather** – this extends the duration of offshore tasks by prohibiting work and increases the number of hours personnel spend offshore

A number of techniques can be deployed to reduce, control and, or, mitigate the risk to personnel. Those methods which have proven successful include regular updating of job cards and work and emergency plans throughout the project; (continued) use of permit to work systems, toolbox talks, sharing of experience and learnings, and technology improvements and training. Consideration might be given to use of the Safe Working Essentials[13], a suite of tools developed by Step Change in Safety (a UK organisation) as part of the drive to simplify/standardise approaches across industry.

7.3 Key Safety Lessons Learnt

Health and safety experience gathered through decommissioning projects has been developed into a number of lessons learnt noted below. This list has been developed from across the decommissioning process and whilst it is not exhaustive, it highlights some of the common themes that practitioners should be aware of.

- Contractors, including management and operatives, should be involved at an early stage of planning. Good communication between operators, contractors and sub-contractors is vital.
- Health and safety of personnel must be the first priority of every person working on the decommissioning project.
- Preparation for decommissioning should begin whilst the platform is still in operation to properly map and document the state of facilities.
- Due to the nature, age and environment of the SPJs in the North Sea Region, there may be issues surrounding structural integrity, which are unknown. These must be dealt with without compromising health and safety. This will entail method changes, mobilisation of additional resources, and rescheduling of operations.
- The interface risks of using tools from different vendors must be considered when using remotely operated vehicles (ROVs), alongside the training of sufficient pilots and technicians.
- The high-level 'decommissioning programme' plan should be supplemented by individual topic plans e.g. a safety case plan. The rate of change of drawings and documents (safety case, risk assessments, emergency route drawings etc.), which can be rapid, should be planned for.
- It is important to maintain the correct safety culture and awareness of process safety risks during decommissioning when there may be significant changes in POB and crews. (Weekly sessions can provide a mechanism for engagement and communication, particularly about process safety hazards).

[13] https://www.stepchangeinsafety.net/about-step-change-safety/steering-groups/simplification

8 Environment

8.1 Overview

In the UK, the decommissioning programme prepared by the licensee must include an Environmental Impact Assessment (EIA). The EIA should identify the likely environmental and societal impacts of decommissioning activities and any long-term effects on the marine environment. They should propose mitigation measures to avoid, or reduce to acceptable levels, any significant effects. The EIA should also assess cumulative impacts as well as those that have the potential to affect marine protected areas (MPA) and any sensitive features in the vicinity of the installation. For SPJ decommissioning, the EIA will consider the impacts of jacket removal, as well as the different methods to achieve the end state, including the ultimate fate of the recovered waste streams.

The regulations of the Norwegian Petroleum Activities Act of 1996 also require that an environmental impact assessment (EIA) be carried out as part of the preparation for decommissioning assets including SPJs[14]. Similar requirements exist in Denmark and The Netherlands[15].

In the case of an OSPAR derogation application, the environmental impacts of different disposal options must be outlined through a comparative assessment. At present, the options available are full jacket removal or removal to the footings (see Section 4). In some cases, the *leave in place* option may be considered to provide a base case scenario for comparison purposes.

The potential environmental impacts and areas for mitigation that are considered as part of the EIA are highlighted below.

8.2 Environmental Impacts

8.2.1 Gaseous Emissions / Energy Usage

Emissions primarily of CO_2, but also smaller quantities of CO, NO_x, SO_x, and VOC, occur during fuel combustion in the vessels performing decommissioning tasks, such as cutting, lifting and transportation. These may cause local deterioration in air quality and have broader environmental consequences. In 2015, CO_2 emissions from the UK offshore oil and gas industry represented 3 per cent of the total UK CO_2 emissions [EEMS data]. Emissions estimates are included in the decommissioning EIA on a project-by-project basis.

For the SPJ, the EIA would also include an estimate of the amount of energy required (and consequent greenhouse gas emissions) to recycle the recovered steel and to replace any left in place.

[14] Guidelines for Offshore Monitoring, KLIF, TA 2849, 2011.

[15] Overview of International Offshore Decommissioning Regulations, Volume 1 – Facilities. IOGP Report 584, July 2017.

8.2.2 Discharges to the Sea

Discharge of sewage and food waste, ballast water and treated bilge water may occur during vessel operations. These would cause localised and transient deterioration in water quality, but pose no real long-term hazards to birds, fish, seabed communities or plankton. Any chemicals that may be used to clean and flush pipework, or to remove jackets and topsides, are permitted through Offshore Chemical Regulations and the potential effect on the environment is considered as part of the permit application process. All discharges to sea during decommissioning operations are permitted activities that are regulated by OPRED-BEIS in the UKCS.

8.2.3 Underwater Sound

Underwater sound is generated from vessel operations, particularly from the use of dynamic positioning systems, as well as from cutting and seabed excavation works. Sound generated during decommissioning activities is likely to be localised, of lower intensity and shorter duration than that generated during installation operations. However, the potential for sound to cause disturbance to marine mammals should be assessed in the EIA and appropriate mitigation proposed.

8.2.4 Physical Disturbance to the Seabed

Some disturbance to the seabed around jacket legs may be required to gain access for cutting piles and legs prior to lifting. This will impact on the organisms that live in and on the seabed. The likely magnitude and duration of this impact depends on the extent of the excavations and would be assessed in the EIA.

8.2.5 Dismantling, Recycling and Disposal

Dismantling decommissioned jackets onshore may result in a variety of aesthetic issues such as visual impacts and generation of odour and noise. There will be consequential increases in road traffic around the dismantling yard to remove dismantled materials with resulting emissions. Whilst it is likely that most of a jacket would be recycled, there may be some materials that would be consigned for disposal, such as concrete grouting and marine growth.

The extent to which these issues are significant depends on the location of the onshore facility in relation to surrounding communities. This would be assessed within the EIA.

8.2.6 Debris / Dropped Objects

During SPJ cutting and lifting operations there is the risk that some larger objects may accidentally be dropped into the sea. Such objects, plus any infrastructure that is not removed, could interact with fishing gear. Side scan sonar and ROV surveys are used to help identify objects for recovery following decommissioning, prior to conducting a trawl-sweep to confirm the seabed is free of debris arising from decommissioning activities.

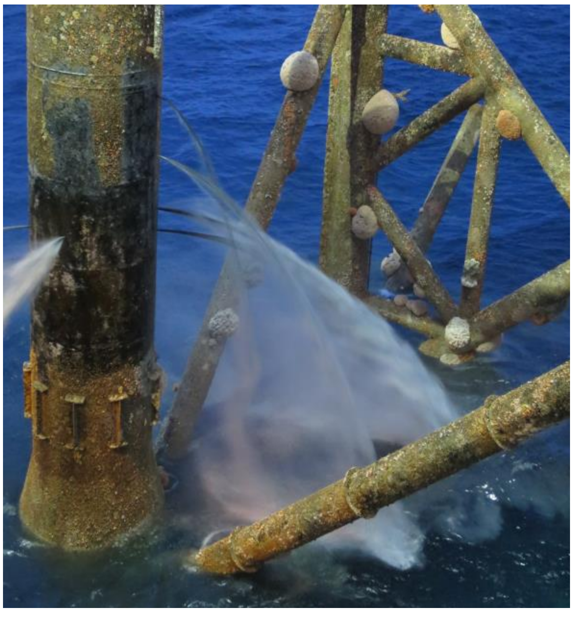
8.3 Rare and Protected Species

The cold-water coral *Lophelia pertusa* and reef-forming worm *Sabellaria spinulosa* have been extensively recorded on or around offshore installations in the northern North Sea Region (see Figure 3). Both species are protected by the EC Habitats Directive[16].

Pre-decommissioning survey work would determine whether these organisms are present. The potential impact of jacket removal on such species should then be covered by the EIA, with mitigation measures proposed to minimise disturbance.

The presence of any such species would also result in a habitats regulation assessment by OPRED during its review of the decommissioning programme. This would be followed by an agreement between OPRED and the operator on the most appropriate mitigation measures. The regulations do not apply to artificial habitats created by the subsea infrastructure itself.

Figure 3: The Cold Water Coral *Lophelia Pertusa* on the Murchison Jacket



Source: CNR International

8.4 Drill Cuttings Management

Where present, drilling cuttings piles may be disturbed during excavation around the jacket base to enable cutting and lifting. Such excavations can result in suspension of cuttings, which will resettle onto the seabed. The significance of this depends on the composition of the drill cuttings pile and the scale of any clearance operation. The options and likely impacts would be assessed through the EIA process and discussed with regulators.

OSPAR Recommendation 2006/5[17] requires that the rate of oil loss and the persistence over the area of seabed contaminated from each pile be assessed. Where the rate of loss and persistence are both below the thresholds set in the Recommendation 2006/5, the cuttings pile may be left in-situ to degrade naturally. If the assessment indicates the thresholds may be exceeded, a comparative assessment of the different options for management of the drill cuttings piles is completed. This is usually combined with consideration of the effects of any jacket removal options on the cuttings pile.

[16] See http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm.

[17] OSPAR Recommendation 2006/5 on a Management Regime for Offshore Cuttings Piles, Meeting Of The OSPAR Commission Stockholm: 26-30 June 2006.

As part of recent decommissioning programmes, to improve the efficiency and effectiveness of the pre-decommissioning surveys of cuttings piles, geophysical mapping of the piles has been carried out first and the data used in real time to design the location of sample points of the piles. This data validates models of the contamination extent of the cuttings pile in the marine environment. The models can be further modified to estimate potential contamination from movement or disturbance of the piles.

Environmental surveys are carried out pre-and post-decommissioning. Such surveys at the Northwest Hutton site indicate that there has been a decrease in the hydrocarbon content in the cuttings piles and an increase in the macro faunal communities over the ten-year period 2002–2013 following the decommissioning of the jacket.

An analysis of the effects of drill cuttings piles at 19 platforms on the UKCS has shown that effects were limited to within 1 km from the platform and persisted for six to eight years after discharge of the cuttings[18]. This work shows that the area around the cuttings can be expected to gradually recover naturally and the spatial extent of contamination to diminish over time.

[18] Historic scale and persistence of drill cuttings impacts on North Sea benthos, Henry et al https://doi.org/10.1016/j.marenvres.2017.05.008.

9 Reuse Recycling and Onshore Disposal

A fundamental element of OSPAR Decision 98/3 is that reuse and recycling are the preferred options ahead of onshore disposal for disused offshore structures. This is also consistent with the European Commission's Directive 2008/98/EC on waste (Waste Framework Directive)[19], which is built around a 'waste hierarchy'. The oil and gas industry has demonstrated its commitment to this treatment of waste when decommissioning redundant facilities and, in particular, with respect to SPJs.

The management of waste is relatively simple for steel jackets when compared to topsides, which typically produce complex and varied waste streams, including hazardous materials such as NORM (naturally occurring radioactive materials) and asbestos. Such materials are not usually present in a steel jacket structure.

9.1 Reuse and Recycling

Reuse is the preferred option for disused offshore structures, but finding alternative uses for structures that are at the end of their intended life is difficult. Aside from identifying a suitable alternative purpose for a facility, technical and economic issues around integrity and long-term maintenance often limit the viability of alternative options. There has been success among some operators in the reuse of small gas processing topside facilities from southern North Sea platforms within their own developments[20], but repurposing of jackets *in situ* is rare.

One example of re-use however is the *Platforms Naturally* project proposed by Engie and partners in the Dutch Sector of the southern North Sea. This proposal will include leaving two shallow water platforms in place after decommissioning as a marine research site. The two platforms will be left in place for 15 years before final removal[21].

Recycling the materials recovered when a jacket has been removed is consistent with steel recycling practice. The structure is cut into suitably sized sections and the steel, usually free of significant contamination, can be sent directly for recycling. The rate of reuse and recycling on Ekofisk 2/4S, Ekofisk West 2/4D, and Murchison was in excess of 99 per cent.

9.2 Onshore Disposal

Numerous sites are available in the countries bordering the North Sea for dismantling oil and gas facilities. These sites are well established and operate within a strict health, safety and environment regulatory regime that ensures that people and the environment are protected during onshore disposal works. Safety and environmental issues associated with onshore disposal activities are highlighted in Sections 7 and 8.

In the UK, yards come under the Environmental Protection Act 1990 and subsequent legislation covering pollution prevention, handling hazardous materials and transportation of waste and are

[19] http://ec.europa.eu/environment/waste/framework/.

[20] Reuse of Decommissioned Offshore Facilities, Platform Brokers, August 2011.

[21] http://www.engie-ep.com/en/technologies-and-innovations/restore-nature/platforms-naturally.aspx.

subject to regular audit and inspection by the HSE and environment protection agencies, (the Environment Agency in England and Wales, and the Scottish Environmental Protection Agency in Scotland).

Onshore disposal represents a small part of the decommissioning process and employs relatively small numbers of personnel in semi-automated sites that can rapidly process recovered structures into their individual waste streams. As shown in Figure 10, onshore disposal, along with remediation of the site and monitoring mounts to 2% of the estimated overall cost of decommissioning.

10 Technology

Along with safety and environmental criteria, the availability and capability of technology continue to be dominant factors when evaluating decommissioning options for SPJs. The main technological areas that influence option evaluation for SPJ decommissioning are:

- Cutting offshore and subsea
- Offshore lifting

10.1 Cutting Technologies

10.1.1 Overview

The ability to cut large and complex steel sections in offshore environments, often subsea, is fundamental to the decommissioning process. The thicknesses of sections to be cut vary from a few centimetres to many metres in diameter.

There are three main types of cutting equipment used in SPJ decommissioning activities:

- Diamond wire
- Abrasive water jet
- Hydraulic shear.

High safety standards dictate the design of equipment and their procedures for use. The tool selected depends on the size of the section that needs to be cut, access constraints, the desire to execute the cutting phase quickly and the need to minimise risk exposure to offshore personnel.

The current capability of these different technologies is described below.

10.1.2 Diamond Wire

Diamond wire can allow complex cuts to be performed, including, for example, castellated cuts. Currently diamond wire tooling is available for subsea cuts up to a maximum diameter of 7.3 metres.

The Murchison jacket removal campaign made extensive use of diamond wire cutting techniques. A bespoke diamond wire tool was developed to cut the 6.0 metre diameter jacket legs above the footings, the first time the technology had been applied on this scale. This extension of existing cutting technology allowed the upper jacket sections to be removed using a heavy lift vessel (HLV).

10.1.3 Abrasive Water Jet Tools

Similar to diamond wire, abrasive water jet tools can also make sophisticated cuts and are capable of cutting sections up to 1.8 metres of piles externally. This method is also well suited for performing internal cuts inside piles or jacket legs when access is available. For such internal cuts, the maximum diameter for an abrasive water jet tool is 3.0 meters in diameter. Under certain circumstances, these tools can be deployed up to 3.0 meters below the mudline to internally cut piles.

10.1.4 Hydraulic Shear

The fastest technology for cutting steel sections is the hydraulic shear, which has been used extensively in both platform and pipeline decommissioning projects to date. Maximum external cuts of up to 1.5 metres have been achieved subsea.

During the Murchison jacket removal campaign, a hydraulic shear was used to sever and crimp vertical flowline riser bundles that formed part of the removal work scope. The severing tool was used to crimp the riser when it was cut which stopped any internal pipework, control lines and spacers from falling from the riser, thus mitigating the dropped object risk.

10.1.5 Summary

The cutting industry continues to develop an array of tools for SPJ decommissioning tasks, with projects often using a variety of cutting techniques during removal works. For the Northwest Hutton jacket removal, BP's contractors used a combination of diamond wire, abrasive water jets and hydraulic shears to perform 248 cuts to remove the jacket sections. As operators and contractors gather more experience and technology develops, cutting scopes become more efficient and cost effective.

The experience on Murchison shows that technology is available to cut the legs of the largest steel jackets above the footings. It is noted however that the cutting of clusters of piles within the footings of such structures, several metres below the seabed remains beyond the limits of current technology. The derogation categories within current regulations that allow the footings of the largest SPJs to be left in place therefore remain appropriate.

10.2 Lifting Technologies

The ability to lift large sections of steel structures offshore remains a major criterion for selecting decommissioning options under the current regulatory regime.

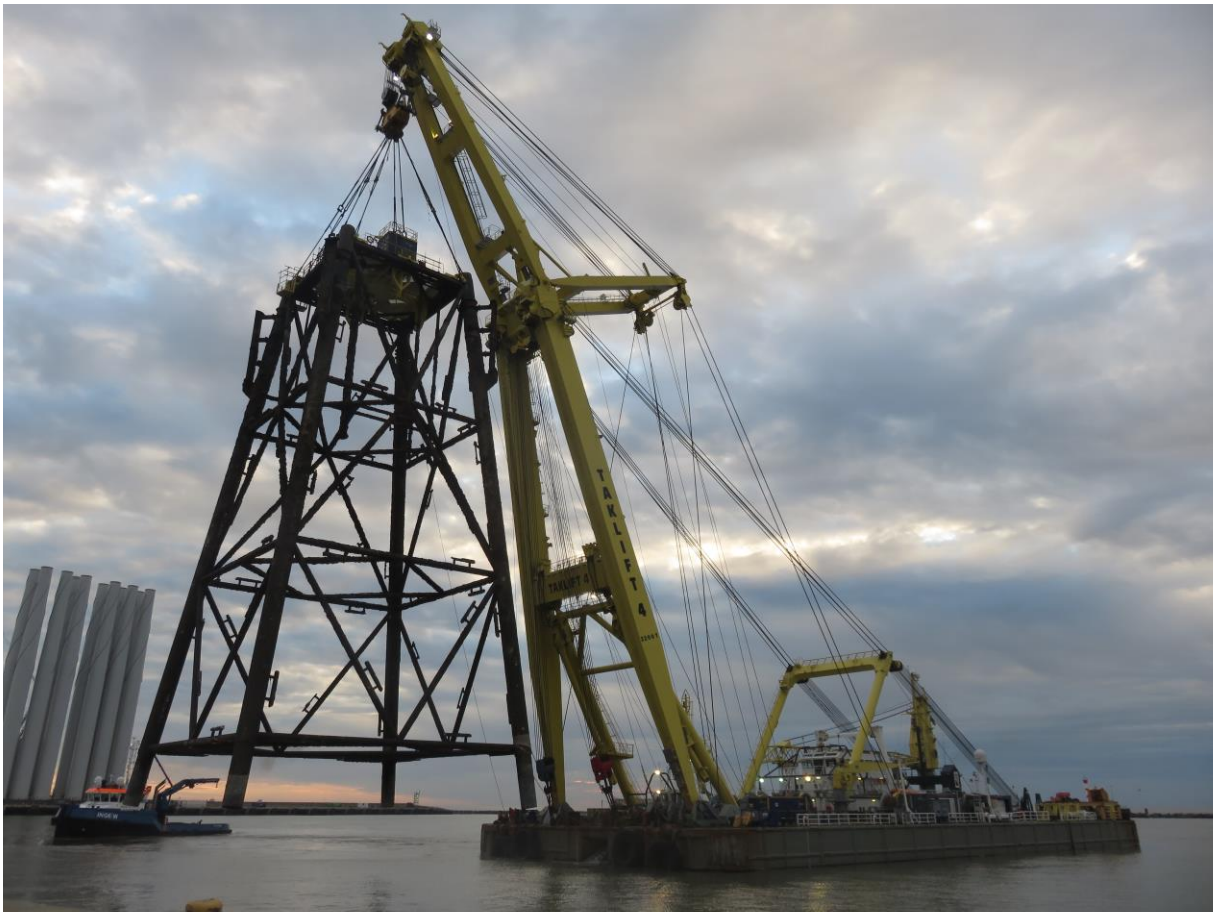
The primary lifting solution is the use of a heavy lift vessel (HLV) for the removal and transportation of complete or large sections of steel platforms. Other jacket removal methods used to date have included floatation systems requiring the installation of temporary buoyancy, such as the tanks used to remove the DP2 platform on Total's Frigg project.

The current range of lifting vessels available and plans for further developments in lifting technologies are described in this section.

10.2.1 Heavy Lift Vessels

A range of heavy lift vessels have been used in decommissioning practices in the North Sea Region. Vessels such as *sheerlegs* and *monohulls* have lifting capacities of up to 5,000 tonnes and are ideally suited for single lift operations in the southern North Sea. A typical heavy lift vessel suitable for southern North Sea operations is shown in Figure 4.

Figure 4: The Lift Vessel Taklift 4 with Shell's Leman Jacket



Source: Boskalis

The largest heavy lift vessels sometimes referred to as *semi-submersible crane vessels* (SSCV) are equipped with tandem cranes and typically have a total crane capacity in excess of 14,000 tonnes; for example Saipem's S7000 (see Figure 5) and Heerema Marine Contractor's Thialf (shown in Figure 9).

Figure 5: Saipem S7000 Heavy Lift Vessel

Source: Saipem

It is worth noting that the actual lifting capacity of any lift vessel will depend on the geometry of the lift and the length of the crane's reach from the base of the crane pedestal. When a structure is in its offshore location, control and flexibility of lift geometry is not always available and lifting capacity will be less than during installation. Lifting capacity is also down rated when hooks and blocks are deployed under water. Typically, heavy lift vessels have removed large jackets in sections, however, smaller jackets have been removed completely in a single lift. The single lift of Shell's Leman jacket in the southern North Sea is shown in Figure 4.

10.2.2 Single Lift Vessels

The latest development in lifting capability is the lift vessel 'Pioneering Spirit'. Commissioned in 2016, it performed the largest single offshore lift in April 2017 removing the 24,000 tonne Brent Delta topsides from the supporting gravity-base structure. Although performing similar operations as a SSCV, Pioneering Spirit is often referred to as a 'single lift vessel'.

Currently, Pioneering Spirit is not equipped to lift steel jackets in a single lift. Allseas, the owners of Pioneering Spirit, have stated that the jacket lift system with a lifting capacity of 20,000 tonnes will be available on the vessel in 2019.

Figure 6: Allseas Pioneering Spirit Single Lift Vessel

Source: Allseas

10.2.3 Lifting Capacity – Future Developments

Further developments are planned in the heavy lift markets. In terms of SSCVs, Heerema Marine Contractors has published details of its new HLV, *Sleipnir*, which is under construction and understood to have a lifting capacity of 20,000 tonnes and is expected to enter service in 2019[22].

In the single lift sector, Shandong's Twin Marine Lifter is currently under development and is planned to enter service in 2019. The vessel is designed to lift topsides, jackets and other subsea structures, with a maximum lifting capability for jackets of 15,200 tonnes and topsides of up to 32,000 tonnes (See Figure 7).

[22] See: https://hmc.heerema.com/fleet/sleipnir/.

Figure 7: Shandong Twin Marine Lifter

Source: Shandong

Other single lift systems include *Versatruss*, which has been used for both installation and decommissioning projects in the Gulf of Mexico. This system utilises two matching barges with a total lifting capability of 20,000 tonnes.

Allseas has also published images and plans for their next single lift vessel, *Amazing Grace*, with a planned lifting capacity of 72,000 tonnes, with Allseas suggesting the vessel will be available in 2021 or 2022 (See Figure 8).

Figure 8: Allseas Amazing Grace Single Lift Vessel (foreground)

Source: Allseas

10.2.4 Buoyancy Tank Assembly

The buoyancy tank assembly or BTA removal method works by adding buoyancy to the jacket and re-floating it in one piece. The Frigg DP2 jacket was removed by Aker Solutions using this method, and transported to a Norwegian fjord where it was then dismantled. This is the only use of this system to-date.

10.2.5 Other Technology Developments

As decommissioning activity has increased, contractors and operators have been developing ‘enabling’ technologies to solve technical problems and reduce risks during the process of decommissioning. Two examples of such problem solving technology were developed and applied during the Murchison jacket decommissioning.

The contractor was looking for a simple and effective way to attach rigging to the lower sections of the Murchison jacket following removal of the upper sections. A bespoke external gripper was developed which was part of the lift vessel’s rigging and was hydraulically latched on to the top of the jacket leg below sea level, allowing the sections to be lifted without diver intervention. The hydraulic connectors are shown in Figure 9.

Similarly, additional jacket clamps were installed on the HLV for use during the transit of the Murchison jacket from the Murchison field to the disposal yard. The clamps secured the bottom sections of the jacket to the Heavy Lift Vessel whilst it was suspended on the crane hooks. The hydraulically actuated clamps were activated once the vessel was ready to transit, enhancing the stability of the vessel during the transit phase.

Figure 9: Murchison Jacket being Lifted by Thialf

Source: CNRI

11 Long-term Monitoring

Under OSPAR Decision 98/3, Annex 4, any permit issued for the derogation of all, or part, of a disused offshore structure should contain details of the monitoring requirement post-decommissioning. There is no requirement for monitoring once a structure has been fully removed.

To meet the requirements of Annex 4 of Decision 98/3 and to be consistent with UK regulatory guidance[23], operators on the UKCS must inspect the facility prior to decommissioning to provide a reference point for subsequent inspections.

For SPJs, this will involve the inspection and clearance of any debris from the seabed. Typically, the seabed is then dragged using a chain trawl to confirm that no obstructions remain. For longer term monitoring of derogated footings, a bespoke plan is agreed between the operator and the regulator based on pre- and immediately post- decommissioning survey findings.

In Norway, guidelines from the Norwegian Climate and Pollution Agency (KLIF) require that two environmental surveys be performed after cessation of production at three-year intervals. As with the UK authorities, exact survey requirements are agreed between the operator and the regulator.

In all decommissioning cases across the North Sea Region, the facility operator must also advise mariners and the responsible hydrographer's office of the change in the facility's status, whether it is to be wholly or partially removed, so that navigational charts can be updated.

Ongoing monitoring typically collects data from various sources including:

- Pre-decommissioning survey data;
- Post-decommissioning survey data;
- Reports from other users of the sea;
- Regulator updates;
- New technologies.

Data from these sources will typically be included during regular risk assessments. Required statutory information is delivered to relevant stakeholders and relevant mitigation actions are identified. These may include:

- Updates to and/or validation of existing FishSAFE[24] / Kingfisher data
- Updates to and/or validation of existing hydrographic charts
- Maintaining exclusion and/or advisory zones
- Offshore site monitoring (survey data)
- Liaison with other sea users (e.g. SFF)
- Review of existing regulations
- Liaison with other operators and bodies (for example Oil & Gas UK).

[23] Guidance Notes: Decommissioning of Offshore Oil and Gas Installations and Pipelines under the Petroleum Act 1998, DECC, Version 6, March 2011.

[24] The FishSAFE web site has been developed by FLTC Services Limited to promote fishermen's awareness of offshore surface and subsea structures within the UK Continental Shelf http://www.fishsafe.eu/en/contact-us/about-us.aspx.

The monitoring process, the risk assessments and mitigation actions are designed to reduce the likelihood and severity of any incident.

12 Public Consultation

There is a statutory requirement for operators in the UK to consult with stakeholders to gather their views on the proposed decommissioning options. In planning for a public consultation, operators refer to the OSPAR Decision 98/3 on the Disposal of Disused Offshore Installations[25] and the UK Guidance Notes[26]. Statutory consultation in the UK begins once the draft decommissioning programme is submitted to OPRED] and typically lasts for 30 days. The results of consultations are then reported in the decommissioning programme when it is submitted for final approval.

In Norway, the Regulation to the Petroleum Act requires a separate impact assessment programme to be prepared and subject to a 12-week public consultation. This ensures the public are properly informed and provides various stakeholders with the opportunity to input into the project. The final impact assessment report is also subject to a 12-week public consultation.

Further guidance regarding the UKCS can be found in the *Guidelines on Stakeholder Engagement for Decommissioning Activities* on the Oil & Gas UK website at www.oilandgasuk.co.uk.

[25] OSPAR Decision 98/3 on the Disposal of Disused Offshore Installations, Ministerial Meeting of the OSPAR Commission, Sintra, 22 to 23 July 1998.

[26] Guidance Notes: Decommissioning of Offshore Oil and Gas Installations and Pipelines under the Petroleum Act 1998, DECC, Version 6, March 2011

13 The Cost of Steel Piled Jacket Decommissioning

Decommissioning of oil and gas infrastructure in the North Sea is in its early stages with around 10% of steel platforms decommissioned to date and more platforms being installed year-on-year. In the absence of substantial data points, it has not been possible to develop accurate benchmarks for the main elements of the decommissioning process, albeit the trends are apparent.

In the Oil & Gas UK annual survey of activity in the UK sector of the North Sea, the estimated total cost of decommissioning has increased from £26 billion in 2010[27], to £50 billion in 2016[28] on an unrisked basis. The cost growth in the intervening years has been driven by greater clarity on scope, experience and general cost inflation. The Oil and Gas Authority published its own probabilistic cost estimate in 2017[29], which suggested a total cost (P50) of £59 billion to decommission the infrastructure currently in the UKCS. This apparent constant evolution of cost is symptomatic of the uncertainty that still exists around scope and risks associated with decommissioning.

The cost of removing steel-piled jackets is included in the 'Platform Removals' element shown in Figure 10 and amounts to around 5% of the forecast decommissioning spend between 2016 and 2025; topside removals accounted for the other 10% of this cost element.

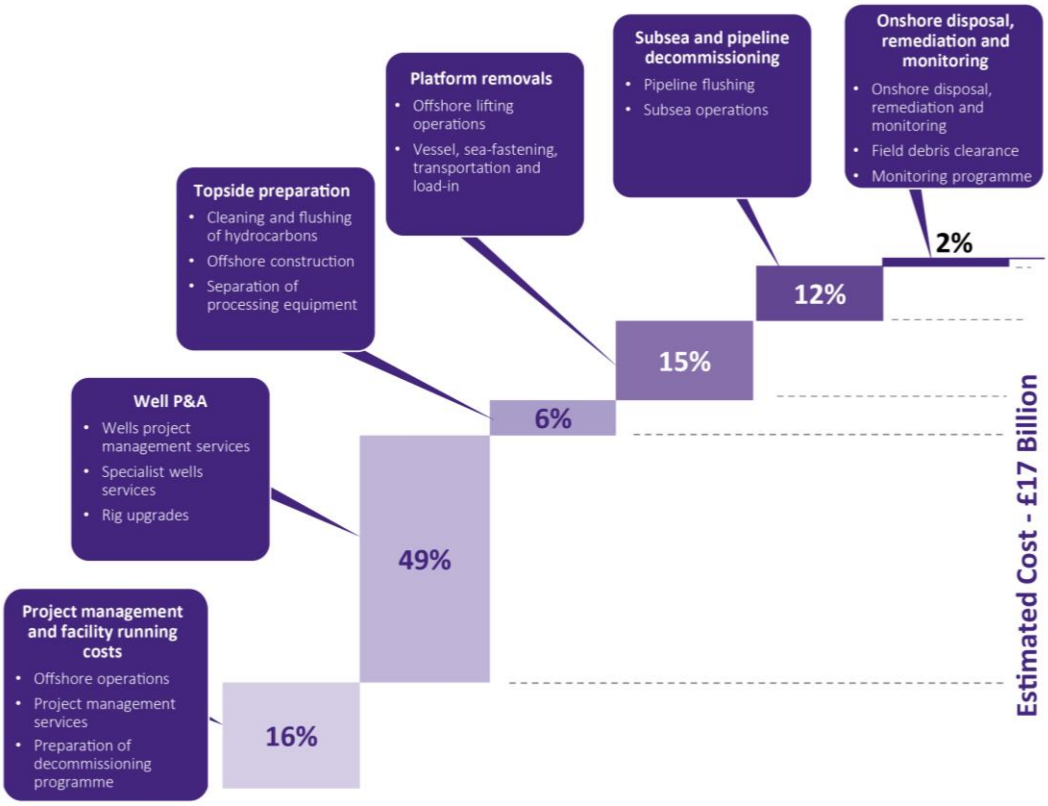
As the number of decommissioning projects increases, the range and capability of technology is increasing, along with a better understanding of scope and risk. In recent projects, these factors have yielded substantial cost savings and the gains are expected to continue as the number and range of completed projects increases. In expectation of continuous improvements in cost efficiency, the OGA and industry are collectively seeking to reduce total cost by at least 35% from that contained within the OGA's P50 estimate.

[27] 2010 Activity Survey, Oil & Gas UK.

[28] 2016 Activity Survey, Oil & Gas UK.

[29] See: https://www.ogauthority.co.uk/news-publications/publications/2017/ukcs-decommissioning-2017-cost-estimate-report/.

Figure 10: Decommissioning Cost Estimate Breakdown - 2016-2025



Source: Oil & Gas UK

14 Case Studies

14.1 Miller Jacket

Platform Details	
Operator	BP
Location	Central North Sea
Water Depth	103 metres
Topside Weight	28,732 Tonnes
8 Legged Steel Jacket	18,584 Tonnes
Height:	~90m jacket, ~20m footings, piles ~55m below seabed

Timeline	Year
Field Discovery	1982/83
Platform Installation	1991
Field Start-up	1992
Cessation of Production	2007
OSPAR Consultation Completed	2011
Decommissioning Programme Approved	2011
Removal	TBC

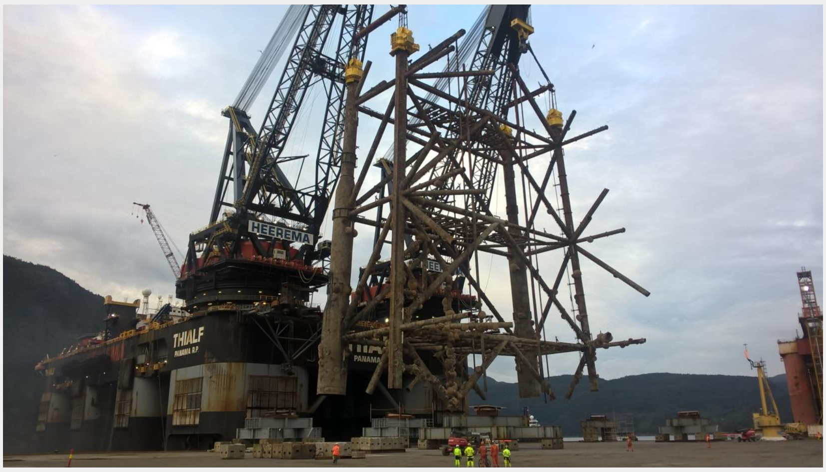
The Miller jacket meets the criteria for derogation under OSPAR Decision 98/3 both in terms of jacket weight and age. The case for derogation was supported by the comparative assessment, which considered both full and partial removal of the jacket.

The comparative assessment confirmed that the preferred option for decommissioning the Miller jacket was partial removal of the jacket to the top of the footings and leaving the footings and drilling template in place. Derogation was granted in 2011 following public consultation.

Both full and partial removal of the jacket requires an intensive period of offshore activity involving a large number of vessels, equipment and personnel. The activity is technically challenging, as Miller is one of the heaviest steel jackets to be decommissioned in the North Sea. Removal of the jacket footings would present additional complexity and involve the disturbance, displacement or removal of the cuttings pile from around the base of the legs. The evaluation of the different jacket decommissioning options was built around the main criteria of safety (to those performing the decommissioning and other users of the sea), environmental and societal impact and economics.

14.2 Murchison Jacket

Platform Details	
Operator	CNRI
Location	Northern North Sea
Water Depth	156 metres
Topside Weight	24,584 tonnes
8 Legged Steel Jacket	24,640 tonnes plus 3,007 tonnes (piles)
Height	162 metres (module support frame to mudline)



Timeline	Year
Field Discovery	1975
Platform Installation	1980
Field Start-up	1980
Cessation of Production	2014
OSPAR consultation completed	2014
Decommissioning Programme Approved	2014
Well P&A	2016
Removal	2016-2017

The Murchison jacket weight and installation date meant that operator CNRI could apply for derogation under OSPAR Decision 98/3 to decommissioning the footing of the structure in situ. This was granted in 2014 and the jacket was subsequently removed down to 44m above the seabed (EL -112m below LAT). The upper sections were recovered to shore for reuse, recycling and final disposal.

The comparative assessment used both quantitative and qualitative data to develop a balanced assessment across the main criteria of safety, technical feasibility, environmental impact, societal impacts and the economics of both full and partial removal of the jacket. As none of the available decommissioning methods could remove the whole jacket in a single piece, the comparative assessment considered options to remove the jacket down to the top of the footings in large sections and then use a heavy lift vessel (HLV) to remove the remaining footings in smaller sections.

Assessment showed that removal and recovery methods for the Murchison jacket footings, including the 3,000 tonne bottle leg assemblies do not have a demonstrable track record. This would therefore mean a higher probability of failure for full jacket removal than partial jacket removal. The cost of full jacket removal would also be 75% higher than the cost of partial removal.

The long-term risk to fishermen from the potential snagging of their fishing gear on the remaining footings was found to be low. The risk is mitigated by supporting the FishSAFE system that provides up-to-date electronic mapping of oil and gas subsea and surface infrastructure in UK waters which may be a potential hazard to fishing vessels or their equipment.

14.3 West Ekofisk, EKOD (2/4D) Jacket

Platform Details	
Location	Norwegian Sea
Operator	ConocoPhillips
Water Depth	73 metres
Topside Weight	5300 tonnes
Jacket Weight	3300 tonnes

Timeline	Year
Field Discovery	1969
Platform Installation	1973
Field Start-up	1977
Cessation of Production	1998
Well P&A	1998
Removal	2010-2011

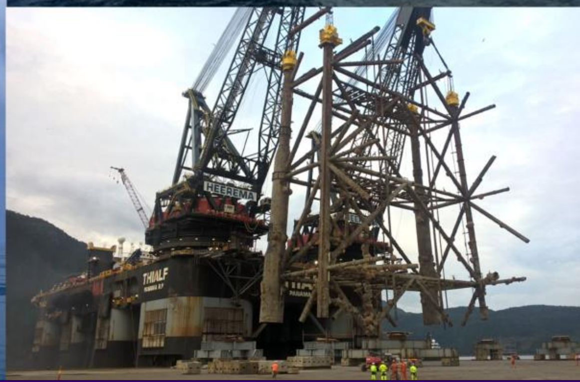
The EKOD drilling, production and accommodation platform formed part of the Ekofisk field located on the Norwegian Continental Shelf. The removal of the topsides and jacket formed part of a larger campaign of ten platforms.

The platform topsides were removed by reverse installation using a heavy lift vessel. The conventional design of the 2/4D jacket consisted of eight legs with steel piles. The jacket had been installed by being upended from a transport barge to a vertical position using a heavy lift vessel. The flotation tanks and legs were then flooded to place the structure on the seabed for piling.

The decommissioning option selected for the jacket was to cut it horizontally into two sections and transport the top part on the deck of the heavy lift vessel and the lower part hanging in the two vessel cranes. The jacket legs and piles on the jacket were cut using diamond wire cutting technology for external cuts and abrasive water jet technology for internal cuts.

The removal method used for 2/4D was similar to that used on the other jackets within the ongoing Ekofisk campaign. Ninety-nine percent of jacket material (excluding hazardous waste) was reused and recycled.

OIL&GAS UK



London Office:
6th Floor East, Portland House, Bressenden Place, London, SW1E 5BH
Tel: 020 7802 2400 Fax: 020 7802 2401

Aberdeen Office:
Exchange 2, 3rd Floor, 62 Market Street, Aberdeen, AB11 5PJ
Tel: 01224 577250 Fax: 01224 577251

info@oilandgasuk.co.uk
www.oilandgasuk.co.uk

ISBN: 1 903 004 97 7