HSE
Health & Safety
Executive

Decommissioning topic strategy

Prepared by **BOMEL Ltd**
for the Health and Safety Executive

OFFSHORE TECHNOLOGY REPORT

2001/032

Decommissioning topic strategy

Ruth Bemment
Bomel Ltd
Ledger House
Forest Green Road
Fifield
Maidenhead
Berkshire
SL6 2NR
United Kingdom

HSE BOOKS

First published 2001

ISBN 0 7176 2054 9

CONTENTS

CONTENTS CONTINUED

CONTENTS CONTINUED

ABBREVIATIONS

ALARP	**As Low As Reasonably Practicable**
ASC	**Abandonment Safety Case**
CGS	**Concrete Gravity Structure**
CHID	**Chemical and Hazardous Industries Division (of the HSE)**
COSC	**Combined Operations Safety Case**
DCR	**HSE Design and Construction Regulations** [10]
DSV	**Diving Support Vessel**
DTLG	**Decommissioning Technical Liaison Group**
DTI	**UK Department of Trade and industry**
EER	**Evacuation, Escape and Rescue**
FOD	**Field Operations Directorate (of the HSE)**
FPS	**Floating Production System**
FPSO	**Floating Production Storage and Offloading System**
GBS	**Gravity Base Structure**
HAZOP	**Hazardous Operations**
HLV	**Heavy Lift Vessel**
HSC	**Health and Safety Commission**
HSE	**Health and Safety Executive**
HSWA	**Health and Safety at Work Act 1974**
IMO	**International Maritime Organization**
LSA	**Low Specific Activity radioactive scale**
MAR	**HSE Management and Administration Regulations** [9]
MCA	**UK Maritime and Coastguard Agency**
MMS	**The Minerals Management Service of the US Department of the Interior**
MSF	**Module Support Frame**
MODU	**Mobile Offshore Drilling Unit**
NWECS	**North West Europe Continental Shelf**
OSD	**Offshore Safety Division (of the HSE)**
OSPAR	**Oslo Paris Convention**
P&A	**Plugging and Abandonment (of wells)**
PFEER	**HSE Prevention of Fire and Explosion, and Emergency Response Regulations** [11]
PSR	**HSE Pipeline Safety Regulations** [34]

ABBREVIATIONS (continued)

ROV	Remotely Operated Vehicle
SALM	Single Anchor Leg Mooring
SCR	HSE Safety Case Regulations [8]
SMS	Safety Management System
SPD	Safety Policy Directorate
SRB	Sulphate Reducing Bacteria
SSCV	Semi Submersible Crane Vessel
TLP	Tension Leg Platform
UKCS	United Kingdom Continental Shelf
UKOOA	United Kingdom Offshore Operators Association
VLSSCV	Very Large Semi Submersible Crane Vessel

HEALTH AND SAFETY EXECUTIVE
OFFSHORE DIVISION

DECOMMISSIONING TOPIC STRATEGY

EXECUTIVE SUMMARY

This study was established under the HSE Framework Agreement April 1998 to assist the Health and Safety Executive Offshore Division with development of a Topic Strategy on Decommissioning of Offshore Installations.

The study began with a review of the technical literature available with the objective of presenting a report to the HSE highlighting the key issues relating to abandonment of offshore installations and identifying knowledge gaps.

An extensive review of the regulatory framework has identified the global, regional (i.e. European) and national regulations pertinent to decommissioning. The UK acceptance in 1998 of the OSPAR Convention has moved the technical emphasis from in-situ disposal by toppling or emplacement to the removal for recycling ashore with an attendant increase in risk to human life. Therefore future efforts need to be directed to controlling these risks by safety management methods and improved equipment reliability and procedures for underwater cutting, heavy lifting operations and the development of rapid or weather insensitive technologies for offshore demolition.

A review is included of the likely decommissioning schedule for all UK sector North Sea installations together with their classification and the weight and water depth of the largest structures affected by the OSPAR decision.

The abandonment process is described as a framework for considering safety management and technical issues related to decommissioning. A previous HSE research summary is reviewed and new issues are identified as a result of recent experience and the changing regulatory requirements.

Principal issues are categorised under the headings of Strategy, Safety Management and Technical and are mapped onto Decommissioning Topic Strategy Objectives as a basis for developing a detailed plan to meeting these objectives.

1. INTRODUCTION

This study was established under the HSE Framework Agreement April 1998 to assist the Health and Safety Executive Offshore Division with development of a Topic Strategy on Decommissioning of Offshore Installations.

This report is structured in the following manner:

- Section One defines decommissioning, the background to the issue together with an outline of the HSE Decommissioning Strategy Area, identifying the seven research objectives related to decommissioning and dismantlement.

- Section Two presents the scope of work for this study and describes each stage.

- Section Three outlines the global, regional and national legislative and regulatory positions, and includes commentary on the OSPAR ministerial decision.

- Section Four provides an overview of the decommissioning issue, lists North Sea installations decommissioned to date, and provides details of the forthcoming UKCS decommissioning schedule.

- Section Five provides details on installation types, categories and removal costs as estimated by the DTI.

- Section Six describes the decommissioning process and the stages involved in the abandonment process.

- Section Seven briefly reviews research carried out by HSE into the topic, and also reports other relevant research.

- Section Eight identifies the issues raised by decommissioning and removal, and categorises them into strategic, safety management and technical areas.

- Section Nine finally maps the issues onto Decommissioning Topic Strategy objectives.

- Section Ten provides a comprehensive reference listing on the decommissioning topic and related issues.

1.1 WHAT IS DECOMMISSIONING?

Decommissioning is the process which the operator of an offshore oil or gas installation and pipeline goes through in order to plan, gain approval for and implement the removal, disposal or re-use of an offshore installation when it is no longer needed for its current purpose [(1)].

It has five distinct stages:

- Options are developed, assessed and selected and put through a detailed planning process that includes engineering and safety preparation.
- The operator has to stop the production of oil or gas, plug the wells deep below the surface and make them safe.
- All or part of the installation usually has to be removed from the site.
- Those parts that are removed have to be disposed of or recycled.
- Seabed surveys are carried out, as well as ongoing monitoring if any part of the platform / facility remains in place.

In summary, decommissioning is the process of deciding how best to shut down operations at the end of a field's life, closing the wells, cleaning up, making the installation safe, removing some or all of the facilities and reusing or disposing of them as appropriate [(1)].

1.2 BACKGROUND

There are strict international, regional and national guidelines and regulations governing the decommissioning process. Most installations will eventually be reused, recycled or scrapped onshore. Each oil and gas installation is unique, designed and built for a particular location, water depth and environmental conditions, and subject to the technology available at the time of design, construction and installation. The remoteness from land combined with deep water and harsh environment makes some of the North Sea and North East Atlantic offshore installations among the largest and heaviest anywhere in the world.

Reaching a decision on the best decommissioning process for each installation and pipeline is a complex, rigorous process demanding the highest degree of responsibility and care in order to balance protection of the environment and other users of the sea with health, safety, technological and economic considerations during decommissioning activities.

The HSE is required to ensure that all risks to personnel associated with the decommissioning process are adequately considered, evaluated and controlled to as low a level as is reasonably practicable.

1.3 HSE DECOMMISSIONING STRATEGY AREA

The HSE Offshore Division (OSD) Research Programme is structured into 20 strategy areas, of which the Decommissioning Strategy Area is one of the five new areas that were added into the 1996 /1997 programme (2).

The offshore industry will eventually totally or partially remove over 200 installations from the UK Continental Shelf (UKCS), taking into account international obligations with respect to the environment, safety of navigation and UK safety legislation. Actual UK experience to date in platform decommissioning, dismantling and disposal is limited to small platforms in shallow waters or floating systems. In the next few years, the first of the large offshore installations, located in much deeper waters and in remote and hostile locations, are likely to be dismantled. The HSE needs to be assured that the risks involved are adequately controlled.

The key to safe decommissioning, dismantling and disposal of offshore installations and pipelines will lie in proper assessment of the risks, and by observing safe systems of work. Many hazards and appropriate risk control measures associated with the decommissioning, dismantling and disposal of offshore installations are similar to those arising from construction or maintenance operations carried out both on and off shore.

Until recently it has been expected that many large steel structures would be disposed of in-situ by toppling using remotely controlled cutting techniques to produce a toppling mechanism at relatively low risk to personnel. However the announcement in 1998 that the UK would comply with the OSPAR convention now means that large steel structures will not be toppled in place and all but the base section with pile bottles (or 'footings' (6)) must be removed (see Section 3.3). Inevitably this will result in the closer proximity of personnel during the most critical decommissioning operations and therefore a re-evaluation of safety priorities in the light of the OSPAR decision is imperative.

1.4 RESEARCH OBJECTIVES WITHIN THE DECOMMISSIONING STRATEGY AREA

Seven research objectives were identified by OSD in 1996 / 1997 within the Decommissioning Strategy Area, as follows:

i. To identify and evaluate the main hazards and risk control mechanisms associated with decommissioning, dismantlement, removal of installations and deferred decommissioning.

ii. To establish with industry the health and safety lessons learnt from the removal of installations in the Gulf of Mexico and other offshore regimes.

iii. To establish with industry the technology for toppling of jacket structures and the implications for risk control, and to validate associated software tools.

iv. To establish with industry the technical criteria and the implications for risk control in the refloating of concrete gravity-based platforms.

v. To investigate the implications to emergency response arrangements of decommissioning and dismantlement.

vi. To establish the reliability of cutting techniques, particularly using explosives, and the factors influencing safe standoff distances and contingency plans.

vii. To appraise heavy lifting operations and their risk implications for the removal of installations.

Of the above, (iii) is no longer relevant to UK waters following the OSPAR decision.

1.5 DECOMMISSIONING TECHNICAL LIAISON GROUP

The HSE has established a divisional working group, the Decommissioning Technical Liaison Group (DTLG), to provide a focal point for the preparation of internal guidance to inspectors and for liaising with other organisations with an interest in decommissioning matters. Division OD5 has topic responsibility within the HSE for decommissioning and the role of facilitating the tasks of the DTLG.

The DTLG purpose is to:

- Be responsible for co-ordination of input to internal guidance to inspectors on matters relating to decommissioning and dismantlement of offshore installations and pipelines
- Recommend and encourage initiatives to improve health and safety during decommissioning and dismantlement of offshore installations and pipelines
- Perform specific tasks as required by Division senior management.

The DTLG is also responsible for:

- Developing OSD's research strategy and providing a forum for discussion of research proposals
- Facilitating dissemination of relevant information throughout OSD
- Keeping abreast of current and emerging technologies for offshore decommissioning
- Liaising with and providing technical support to the Safety Policy Directorate (SPD) and where appropriate other OSD working groups
- Providing focal point for liaison on technical and operational matters between OSD, Field Operations Directorate (FOD), DTI and Industry.

1.6 MARINE AND AVIATION OPERATIONS GROUP OD5

1.6.1 GOAL

The Marine and Aviation Operations Group within OSD has responsibility for decommissioning and dismantlement. The goal of the group is to secure the safety of those working in the offshore industry by maintaining and improving marine and aviation operations practices, and by enabling effective enforcement by inspectors.

1.6.2 STRATEGIC OBJECTIVES

One of the strategic objectives of this group is to provide inspectors with timely expert advice, guidance and, where appropriate, training on decommissioning and dismantlement of installations, and carriage of dangerous goods.

This study has been undertaken by BOMEL under the HSE Technical Support Framework Agreement to assist OD5 and the DTLG with the development of a topic strategy for decommissioning of offshore installations.

2. STUDY OBJECTIVES AND SCOPE

2.1 OBJECTIVE

The objective of this study is to review the technical literature on decommissioning of offshore installations and to present proposals to HSE OD5 to assist with development of a Divisional Topic Strategy on Decommissioning.

2.2 SCOPE OF WORK

The scope of the study includes the following activities:

1. Literature Search

The principal source of information is literature (including HSE reports) and published work relating to decommissioning. Information was to be gathered primarily on abandonment of North Sea platforms.

Principal sources of information were:

- Previous HSE study reports
- HSE guidance and manuals, and NPD publications
- Conference Proceedings e.g. Euroforum, IBC, OTC, industry group meeting notes (e.g. ODCP, IADC, UKOOA etc.).
- Enforcement Manual (Regulation 7) and other appropriate regulations
- Assessment principles for offshore safety cases
- MaTSU Reports
- Gulf of Mexico published information.

2. Identify Key Findings

Key issues arising from the literature search were to be identified in areas such as:

- Removal/ dismantlement
- Subsea / Explosive cutting
- Refloating of concrete structures
- Planning for abandonment
- Disposal, dumping and handling
- Heavy-lift technology
- Environmental Impact

- Safety and Hazards
- Control of risk
- Best practice
- Non-abandonment options
- Costs.

3. Interim Review Meeting with HSE

An interim review meeting was held with the HSE once literature was assembled and reviewed. Following discussion at this meeting, it was agreed that the report would contain four main sections as follows:

- Legislation and regulations
- Likely decommissioning schedule
- Categories of installation
- Key issues

4. Prepare Draft Report

References were to be listed and referenced, and a draft report prepared. The report was to highlight and prioritise the key issues relating to decommissioning and abandonment of offshore structures, identifying knowledge gaps and recommending a strategy to equip HSE to deal with this topic in the short to medium term.

5. Prepare Final Report

Following discussion with HSE, comments on the draft report were to be incorporated into a final report setting out proposals for a Decommissioning Topic Strategy. This strategy was to be structured along the lines of:

- Where are we now?
- Where do we want to be?
- How do we achieve this?
- How do we measure achievement?
- Priority issues?
- Knowledge gaps?
- Timing?
- Research activities identified for future action?
- Work areas identified to establish the primary issues with industry and acceptable methods of addressing these?

- Impact of ageing infrastructure, changes in regulations and frontier area developments.

6. Presentation Meeting

A meeting with the HSE to present and review the final report is also allowed for in this scope.

2.3 DELIVERABLE

The deliverable from this study is a report setting out proposals for a Divisional Topic Strategy on Decommissioning of Offshore Installations. This document constitutes this deliverable.

3. LEGISLATIVE AND REGULATORY POSITION

3.1 INTRODUCTION

The oil and gas exploration and production industry is highly regulated. An extensive worldwide regulatory framework governs the removal and disposal of offshore installations. The framework includes global conventions and guidelines, regional conventions and national laws [3].

The prime global authority is the International Maritime Organization (IMO), with OSPAR the main regional convention covering the North Sea and North-East Atlantic. In addition, the London Convention is the global convention governing the dumping of waste and material at sea. Under certain circumstances, the London Convention governs the issue of permits for the disposal of installations at sea. Finally, national governments have specific laws governing operation, including decommissioning.

The sub-sections which follow set out and briefly describe the relevant provisions by way of background.

3.2 GLOBAL REGULATORY REGIME

The global regulatory regime which has evolved over the past forty years is intended to strike a balance between the need to protect the environment, navigation, fishing and other sea users on one hand, and to take into account safety, technical feasibility and the cost of decommissioning on the other hand.

The global regulatory regime consists of:

- Geneva Convention on the Continental Shelf 1958
  Article 5(5) calls for total removal

- Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter 1972 (London Dumping Convention)
  Controls dumping at sea

- UN Convention on the Law of the Seas 1982 (UNCLOS)
  Article 60(3) permits partial removal provided IMO criteria are met

- IMO Guidelines and Standards for the Removal of Offshore Installations and Structures on the Continental Shelf 1989
  Establishes removal criteria

3.2.1 GENEVA CONVENTION 1958

This states:

“Any installations which are abandoned or disused must be entirely removed”.

As offshore oil and gas production moved into deeper water and more hostile environments during the 1960s and 1970s, it became apparent that absolute entire removal would become unreasonably burdensome. The huge deepwater platforms would be extremely costly and dangerous or impossible to totally remove. Requiring total removal also raised the question of harm to the environment.

3.2.2 LONDON DUMPING CONVENTION 1972

The London Dumping Convention (known as the London Convention (LC)) was developed, at the recommendation of the United Nations, to protect the marine environment from hazards of dumping at sea. Much of the unregulated dumping that occurred before LC came into force in 1975 has largely been halted. The convention applies to all marine waters world-wide other than internal waters of states.

Article III(i)(a) defines dumping as:

“Any deliberate disposal at sea of wastes or other matter from vessels, aircraft, platforms or other man-made structures at sea;

Any deliberate disposal at sea of vessels, aircraft, platforms or other man-made structures at sea”.

However, Article III(ii)(b) provides that dumping does not include *“placement of matter for a purpose other than the disposal thereof, provided that such placement is not contrary to the aims of this convention”.* It is through this article that the Rigs to Reef programme in the Gulf of Mexico is possible.

Article IV prohibits dumping of *“any wastes or other matter”* except as specified in that Article, which prohibits dumping of hazardous substances. The appropriate national authority is granted the right to issue general permits for dumping of other wastes or matters. Considerations set out in an associated annex allow platforms to be considered for sea disposal.

In November 1996, agreement on a new Protocol to the 1972 LC was reached. The new protocol is not yet in force, awaiting ratification by a sufficient number of signature states, and it may be some years yet before it is ratified. Until such time, the 1972 convention is the valid convention.

There are several new concepts worth noting in the 1996 protocol concerning sea disposal:

- The Precautionary Principle suggests that lack of full scientific certainty will not be a good enough reason for postponing cost-effective measures to prevent environmental degradation.

- The Polluter Pays Principle is straightforward in establishing that the polluter bears the cost of pollution and its clean-up.

- The Reverse List states that platforms are among seven specific materials that can be considered for sea disposal. The 1972 LC lists waste that cannot be disposed of at sea.

- The Waste Assessment Framework (WAF) establishes a procedure to be followed in determining whether material on the Reverse List can be disposed of at sea. If it does qualify for sea disposal, the WAF provides guidance for preparation for disposal, site selection, monitoring and permit continuation.

3.2.3 UN CONVENTION ON THE LAW OF THE SEAS 1982

This states:

> *"Any installations or structures which are abandoned or disused shall be removed to ensure safety of navigation, taking into account any generally accepted international standards established in this regard by the competent international organisation. Such removal shall also have due regard to fishing, the protection of the Marine environment and the rights and duties of other States. Appropriate publicity shall be given to the depth, position and dimensions of any installations or structures not entirely removed".*

UNCLOS came into force on 16 November 1994. Under this law, not all structures must be entirely removed, but little guidance is provided as to how the rule should be applied.

3.2.4 IMO GUIDELINES AND STANDARDS 1989

The general principle is that all abandoned and disused installations and structures in the Exclusive Economic Zone and on the Continental Shelf should be entirely removed, except where non-removal or partial removal would be consistent with the Guidelines and Standards. At the time of adoption there were around 450 installations identified worldwide that might be considered as candidates for less than total removal, approximately 7% of the total installation population. Being considered for less than total removal does not mean that the final decision would not be total removal.

These guidelines are a valuable tool, with several points worth noting:

- After 1 January 1998, no platform shall be installed unless the structure's design and construction makes entire removal feasible.

- After 1 January 1998, all platforms installed in less than 100 metres of water (changed from 75 metres) and with a substructure weighing less than 4000 tonnes shall be entirely removed.

- All abandoned or disused structures located in approaches to, or in straits used for, international navigation or routes used in sea-lanes shall be entirely removed.

- In cases of partial removal, the coastal state shall ensure that legal title to parts of the installation remaining is unambiguous and that financial liability for future damages is clearly established.

- These guidelines permit a "rigs to reef" programme or any other new secondary use of a structure.

The IMO Guidelines cover only removal, and only from a navigational safety perspective. They contain no reference to dumping, which is dealt with in the remit of the 1972 London Dumping Convention.

3.3 REGIONAL REGULATORY REGIME

There are fifteen regional conventions worldwide controlling pollution of the marine environment, developed as part of the UN Regional Seas Programme that began in the early 1970s.

The Oslo and Paris Convention (OSPAR) is the relevant convention protecting the marine environment of the North Sea and the North-East Atlantic. This maritime area does not include the Baltic or Mediterranean seas.

3.3.1 OSLO AND PARIS CONVENTION (OSPAR)

The Convention for the Protection of the Marine Environment of the North-East Atlantic (which applies to the whole of the UK Continental Shelf) came into force on 25 March 1998 [4 and 6]. It replaces the 1972 Oslo Convention for the Prevention of Marine Dumping from Ships and Aircraft and the 1974 Paris Convention on Prevention of Marine Pollution from Land-based Sources, both of which were relevant to the issue of disposal of offshore structures, or parts of them, at sea. The new convention, usually referred to as OSPAR, considerably tightens up the international obligations of Contracting Parties to the convention.

The convention does not prohibit the disposal of platform remains at sea, although since 1995 there was a temporary moratorium to this effect between the signatories to the Oslo Convention. This moratorium has now been made permanent as a result of a decision (OSPAR Decision 98/3) reached at the Ministerial Meeting of the Contracting Parties to the Convention held at Sintra, Portugal in July 1998. Under the provisions of the OSPAR Convention such decisions are binding on the Contracting Parties. Paragraph 2 of Decision 98/3 states that the dumping, and the leaving wholly in place, of disused offshore installations within the maritime area is prohibited. Paragraph 3 does however permit consideration of derogations in the case of concrete installations and concrete anchor bases, and for the 'footings' of steel installations weighing more than 10000 tonnes put in place before 9 February 1999.

For installations that have been piled into the seabed, 'footings' refer to those parts of the installation that are below the highest point of the piles, or in the case of installations built without piling, 'footings' mean those parts which form the foundation of the installation and contain amounts of cement grouting similar to those found in piled installations, or which are so closely connected to the parts referred to above as to present major engineering problems in severing them from those parts.

Before any decisions on derogation, Contracting Parties are required to have:

- Carried out a detailed comparative assessment of the position, including consideration of the practicality of alternative solutions, such as re-use, recycling and final disposal on land, and

- Consulted with the other Contracting Parties and taken their views into account, which could involve the holding of a special consultative meeting to address opposing views.

In exceptional and unforeseen circumstances an offshore installation may be disposed of at sea or left in place as a derogation from the main rule. However, this option will only be considered if it can be demonstrated that, due to structural damage, deterioration or some other cause presenting equivalent difficulties, there are significant reasons why disposal is preferable to re-use, recycling or disposal on land[(6)].

Any permit issued by a Contracting Party allowing a derogation must specify the terms and conditions of the derogation, including specifying any necessary subsequent monitoring of the parts left at sea, details of their owner, and specifying the person liable for meeting claims for future damage caused by those parts. The permit must also provide a framework for assessing and ensuring compliance, including the issue of a report following the completion of the disposal-at-sea operations describing how those operations were carried out.

The Decision came into force on 9 February 1999, in effect bringing to an end the UK Government's previous policy of a broad-ranging case-by-case assessment of each decommissioning proposal. In future, re-use, recycling or disposal on land will be the norm [5 and 6], save in exceptional cases where a derogation will be allowed. Toppling and other disposal on the seabed will no longer be options under normal circumstances following OSPAR. Concrete structures installed before 9 February 1999 are likely to be left in place due to safety and technical considerations.

At the Sintra meeting, the environment ministers adopted a new negotiating position in order to move to agreement, after analysis of the science, technology and costs showed that it would normally be practicable to remove, reuse or recycle all smaller steel structures, all topsides and most large steel structures. It was agreed to ban toppling or dumping of structures smaller than 10000 tonnes in the sea [7]. The agreement presumes that larger structures above 10000 tonnes will also be removed and, while footings that anchor large installations to the seabed will have to be assessed on a case-by-case basis, it is also likely that these will require removal. The ultimate aim of OSPAR is to quickly reduce as far as possible the cases for which derogations to the general ban on sea disposal may be considered. All installations emplaced after 9 February 1999 must be completely removed (including concrete structures).

There are upwards of 500 installations in the North Sea, of which over two-thirds are in shallow waters and must be removed under international guidelines for navigational safety. The OSPAR debate has focused therefore on the large deepwater structures, most of which lie in UK and Norwegian waters. Most structures in the North Sea will be removed, but some are so large that they will be difficult to remove without doing further environmental damage and raising significant technological challenges and safety concerns.

The key points of OSPAR are:

- All dumping of platforms at sites remote from E&P activities is banned (from 9 February 1999).
- All toppling of platforms in-situ is banned.
- The category of 'large steel platforms' is re-defined. Previously 'small' was less than 75 metres water depth and less than 4000 tonnes. The differentiation is now based on weight only, with 'large' defined as those platforms with jackets of

more than 10000 tonnes. For large steel structures, only the footings (or bottles) may be left in place, and only where removal is prohibited on safety, environmental, technical and cost grounds, and after an extensive consultation round involving all OSPAR states.

- In future, all new steel structures must be removed entirely.

- Following acceptance of a comparative assessment and derogation application, concrete structures are likely to be able to remain in-situ but there is a presumption that any new concrete structures (installed after 9 February 1999) will have to be designed for removal.

- The provisions of Decision 98/3 do not apply to pipelines.

In practical terms, the removal option has been surrendered for 70 large steel installations that need not have been entirely removed under IMO Guidelines. This does not necessarily mean that all of these installations would have been candidates for toppling or dumping, and it is likely that less than half of them would have adopted this route in the wake of Brent Spar.

Forty-one platforms in the OSPAR area fall into the newly-defined ‘large steel’ category that can be considered on a case-by-case basis, of which 34 are in the UK sector (see Section 4), 5 are in Norway, and Spain and the Netherlands have one each. These are in addition to 29 concrete structures that may remain in situ.

Any government that puts forward a proposal to leave any footings of a large structure in place will have an onerous task through the consultative process with OSPAR.

The next OSPAR ministerial meeting is planned to take place in 2003, when there is provision for Decision 98/3 to be reviewed in the light of experience and technical developments [(6)]. However, in spite of earlier predictions [(15)], it seems unlikely that any large steel structures will be decommissioned in the UKCS or the derogation facility within the Decision implemented before 2003.

3.4 NATIONAL REGULATORY REGIME

Legislation has been enacted in the UK to ensure that the operator of an installation has to apply to the relevant government authorities for a specific licence to dispose of any installation.

The relevant legislation is as follows:

- Prevention of Oil Pollution Act 1972
  Controls discharges of oil

- Control of Pollution Act 1974
  Regulates disposal of special wastes

- Food and Environmental Protection 1985
  Controls dumping at sea

- Petroleum Act 1998
  Requires government approval of abandonment plans for installations and pipelines

- Environmental Protection Act 1990
  Controls releases to the environment

- Radioactive Substances Act 1993
  Controls storage and disposal of radioactive substances.

In addition, subsequent to the Piper Alpha disaster on 6 July 1988, the central recommendations of Lord Cullen's Report on the Public Inquiry into the disaster were implemented in Health and Safety Executive (HSE) regulations. Risks from all offshore work activities must be assessed under the Health and Safety at Work Act (HSWA) 1974 and the Offshore Safety Act 1992. Employers must make suitable assessment of risks.

The relevant regulations are as follows:

- Offshore Installations (Safety Case) Regulations 1992 (SCR) (8)
  Require a safety case for every offshore installation to be submitted for HSE acceptance. Regulation 7 requires a safety case for abandonment.

- Offshore Installations and Pipeline Works (Management and Administration) Regulations 1995 (MAR) (9)
  Broadly based requirements relating to management of offshore installations (fixed and mobile installations, but not subsea).

- Offshore Installations and Wells (Design and Construction etc.) Regulations 1996 (DCR) (10)
  Concerned with integrity of installations and other miscellaneous requirements.

- The Pipeline Safety Regulations 1996 (PSR) [34]
  Has requirements for decommissioning of pipelines in Regulation 14 and notification of decommissioning works in Regulation 22 (2) and (3).

Other offshore legislation has a bearing on decommissioning and dismantlement of installations, including:

- 'Prevention of Fire and Explosion, and Emergency Response on Offshore Installations (1995)' (PFEER) [11]
  Concerned with fire and explosion prevention and emergency response offshore.

There were two major elements in the process of reforming the UK offshore legislative regime. The first was the introduction of Offshore Installations (Safety Case) Regulations 1992 (SCR), requiring submission of a safety case for each installation, including a safety case for abandonment. The second was the progressive replacement of existing offshore legislation with more modern goal-setting legislation by means of new regulations under the HSWA. Each safety case is reviewed by the HSE with a view to formal HSE acceptance. After the expiry of the specified review period, it is unlawful to operate installations on the UKCS unless the relevant safety case has been accepted by HSE.

3.4.1 UK REGULATORY REGIME

UK Government policy on decommissioning has been developed and co-ordinated through an Inter-Departmental Decommissioning Policy Review Committee, chaired by the DTI with representatives from other departments and organisations such as the FCO, MAFF, Scottish Office, Cabinet Office, DETR, HM Treasury, Inland Revenue, MoD and HSE [12]. To ensure proper co-ordination within HSE, OSD has formed a Decommissioning Technology Liaison Group (DTLG).

HSE's Field Operations Directorate (FOD) is represented on the DTLG as it may become involved if installations are brought to UK yards for dismantling. The DTLG role is to facilitate the dissemination of relevant technology within the OSD, to provide technical liaison with industry and other government departments, and to act as a focal point for targeting OSD's research needs.

The abandonment of offshore installations and pipelines is controlled through the Petroleum Act 1998 for which the DTI has responsibility. Before an installation or a pipeline can be abandoned, the owner must obtain DTI approval. This is in addition to any obligations arising under Health and Safety legislation, such as the need to have an Abandonment Safety Case accepted by the HSE. The DTI has developed and issued Guidance Notes for Industry covering the 'Decommissioning of Offshore Installations and Pipelines under the Petroleum Act 1998' [6]. In the Guidance, it is recommended that discussions between the owner / operator and the DTI should commence well ahead of the forecast cessation of production. In the case of a large field with multiple facilities, these discussions may commence 3 years or more in advance. Following this preliminary discussion period, the operator must submit a Decommissioning Programme to the DTI. It may take 9 months from submission of the first draft of the Programme until approval of the final draft is obtained from the Secretary of State (or 18 months for a potential OSPAR derogation case).

In most cases the general rule under OSPAR Decision 98/3 will apply and the Decommissioning Programme will provide for re-use, recycling or disposal on land. A statement is required within the Programme to demonstrate how the principles of waste hierarchy are to be met and to show the extent to which the installation (including the topsides and materials contained within the platform) will be re-used, recycled or scrapped. An Environmental Impact Assessment is also to be included within the Programme.

For more complex cases, and in particular where the owner / operator is seeking a derogation to Decision 98/3, a detailed comparative assessment of the options is required and this will also form part of the Decommissioning Programme.

Mindful of the obligations of the Health and Safety at Work Act (HSWA) 1974, the principal legislation governing safe decommissioning offshore is SCR 1992 Regulation 7 which requires the submission of an abandonment safety case (ASC) and provision of detailed information as per SCR Schedule 5. The ASC must be submitted at least six months before decommissioning can begin.

A safety case must demonstrate that:

- Management systems are adequate
- Audit arrangements are adequate
- Major hazards have been identified
- Risks have been evaluated and measures designed to reduce risk to ALARP.

In addition to SCR, other new offshore legislation has a bearing on decommissioning. PFEER 1995 includes requirements for duty holders to protect their personnel from the effects of fire and explosion, and to have effective evacuation, escape and rescue (EER) arrangements. The adequacy of such arrangements will require assessment before decommissioning can begin.

Regulation 16 of DCR requires that *"the duty holder shall ensure that an installation is decommissioned and dismantled in such a way that, so far as is reasonably practicable, it will possess sufficient integrity to enable such decommissioning and dismantlement to be carried out safely".* DCR 1996 also require new designs to take into account the safety of eventual decommissioning and dismantling, ensuring that structural integrity is maintained during such operations.

The key to safe decommissioning lies in proper assessment of risks and observance of safe systems of work. Planning for safety and demonstrating safety management system (SMS) arrangements are unlikely to require major research. Many hazard and risk control measures required are similar to those arising from construction and maintenance operations both on and offshore. However, sequences vary, and as yet there is arguably no UK experience base.

3.4.2 ABANDONMENT SAFETY CASE

The Assessment Principles for Offshore Safety Cases (13) were developed by the HSE to assist operators with preparing a safety case. Although not compulsory, following these guidelines will normally be enough to comply with the law. HSE inspectors seek to ensure compliance with the law, and may refer to the guidelines as illustrating good practice.

Abandonment is dealt with in Paragraphs 172 to 185. The general principles applied to the assessment of operational safety cases will also broadly apply to the assessment of abandonment safety cases.

It should be noted that:

- The information requirements are restricted to activities that are directly involved with the decommissioning and removal of plant, equipment and structures at the location of the fixed installation

- The health and safety of people involved in the transport and disposal of decommissioned or dismantled items are outside the specific scope of the SCR [Offshore Installations (Safety Case) Regulations 1992]

- The environmental impact aspects of offshore operations are outside the scope of the SCR

- Where mobile installations are involved in the abandonment process, a COSC (Combined Operations Safety Case) may also be necessary.

The sequence of decommissioning and abandonment events should be clearly explained. The abandonment programme should follow a logical sequence, taking account of the progressive reduction in the availability of plant and equipment on the installation. Major hazard risks should have been considered, and hazards may arise at a later stage of the decommissioning process which remove an apparently safe offshore option from consideration.

Consideration should be given to maintenance and verification during the time lag between the end of operations and the start of the abandonment process.

Well abandonment policies will have been described in the operational safety case. Arrangements made by well operators in complying with DCR [Offshore Installations and Wells (Design and Construction etc.) Regulations 1996] will contribute to requirements made by SCR. Well operators must ensure the safe physical condition of wells at all stages of the cycle, from design and commissioning through to abandonment.

Descriptions should confirm the extent and availability of safety systems during the abandonment process. The operational status of safety-related plant, equipment and systems should be summarised. Sufficient detail should be provided to show that the management systems can be implemented.

Additional major accident hazards must also be identified.

3.4.3 SELECTED EXTRACTS FROM SCR

The aim of the Safety Case Regulations (SCR) is to reduce risks to the health and safety of the workforce employed on offshore installations or in connected activities. The Regulations implement the central recommendation of the Cullen Report following the Piper Alpha disaster, requiring that the operator or owner of every offshore installation should be required to prepare a safety case, and submit it for HSE acceptance.

Some relevant extracts are included below in this section.

Abandonment
(SCR Schedule 5 “Particulars to be included in a safety case for the abandonment of a fixed installation”)

Abandonment starts when operations cease, and ends in the removal of either all or part of the installation as agreed between the Operator and the Secretary of State under the 1988 Petroleum Act.

The process can be divided into three main phases:

- Interim Decommissioning before a decision to abandon is made
- Total Decommissioning after a decision to abandon has been made
- Physical Removal.

The safety case required by Regulation 7 is concerned only with the last two phases. The first phase is considered as a revision to the operational safety case as Regulation 9(2).

Combined Operations
(SCR Regulation 2(1) and 2(7))

"… if activity carried out from, by means of or on one of the installations

- *is carried out temporarily for a purpose related to the other installation or installations, or*

- *could affect the health and safety of persons on any of the installations or of persons engaged in an activity in connection with any of the installations".*

Commencement of Operations
(SCR Regulation 4(3))
"… on commencement of the first well drilling operation … or when hydrocarbons are brought onto the installation for the first time through a pipeline or well, whichever is earlier".

Concession Owner
(SCR Regulation 2(1) as amended by DCR Regulation 26)
"… person who … has the right to exploit or explore … mineral resources …"

Connected Activities
(SCR Regulation 2(8)) and Article 4(1)b of the 1995 Order

"any activity, including diving operations, in connection with an offshore installation, or any activity which is immediately preparatory thereto, whether carried on from the installation itself, on or from a vessel or in any other manner, other than –
(i) transporting, towing or navigating the installation; and
(ii) any activity on or from a vessel being used as a standby vessel"

The difference between Connected Activities and Combined Operations should be noted:

… ensures that the particulars required in the safety case submitted under Regulations 4, 5 and 7 address activities carried out, on or in connection with another installation or vessel that is not itself required to submit a safety case and to which Regulations 2(6) and 2(7) do not apply. An example is heavy lift from a HLV alongside an installation (an activity that would be subject to the notification provision of Regulation 12).

Construction Activity
(SCR Regulation 2(1))
"… means …

- *construction of installation at place where it is to be operated*
- *dismantling or demolition of installation where it was operated*
- *activity on or in connection with installation which involves use of HLV".*

Co-operation
(SCR Regulation 14) (Also MAR Regulation 8)
This regulation requires co-operation between operator, owner, any other employer, self-employed person, other operators and owners of connected installations, person in control of stand-by vessel or HLV, and owner of connected pipeline.

Decommissioning
(SCR Regulation 2(1))
"… means …
taking the installation or any plant thereon out of use with a view to the abandonment of the installation, and "decommissioned" shall be construed accordingly".

Fixed Installation Abandonment Safety Case
(SCR Regulation 7)
"… operator … shall … prepare a safety case containing the particulars specified in Regulation 8 and Schedule 5 and send safety case to the Executive at least 6 months before commencing decommissioning".

The safety case required by Regulation 7 is concerned with total decommissioning and physical removal. Interim decommissioning before decision to abandon is a revision to Operations safety case and therefore subject to Regulation 9(2).

"HSE's acceptance of safety case for abandonment … is required, and will be given, independently of other approval(s) the operator is obliged by law to obtain …"

Fixed Installation Design Safety Case
(SCR Regulation 4(1))
"… operator … shall … prepare a safety case containing the particulars specified in Regulation 8 and Schedule 1 and send safety case to the Executive".

Fixed Installation Operations Safety Case
(SCR Regulation 4(2))
"… operator … shall … prepare a safety case containing the particulars specified in Regulation 8 and Schedule 2 and send safety case to the Executive at least 6 months before commencing operations".

Hazards
SCR Schedule 5
Adequate demonstration that due account has been given to assessment of changing hazards, and implications to the safety management system (SMS) of changes to the operational status of installation.

HLV
(SCR Regulation 2(1))
"… means …
a vessel whose primary function is to lift an installation or part thereof, or lift plant onto or off an installation".

New Operator or Owner
(SCR Regulation 2(9))
"… anything done in compliance with … Regulations by operator or owner in relation to … installation shall … be treated as having been done by his successor".

Notification of Construction Activities
(SCR Regulation 12)
Operator must notify HSE of construction activity (Regulation 2(1)) 28 days before commencement, containing information required in Schedule 7. This does not require HSE acceptance.

Operator
(SCR Regulation 2(1))
"(Fixed Installation) … person appointed by a concession owner to execute any function of organising or supervising any operation to be carried out by such installation or ...the concession owner".

Revision of Safety Cases
(SCR Regulation 9(1))
"… operator … shall … revise its contents as often as may be appropriate, but nothing … shall require … revision to be sent to the Executive".

(SCR Regulation 9(2))
"… where … revision .. will render the safety case materially different … safety case (to be) sent to the Executive at least 3 months before revision is to be made".

Safety-critical elements
(SCR Regulation 2(1) as amended by DCR Regulation 26)

"… such parts of an installation and such of its plant … the failure of which could cause or contribute substantially to, or purpose of which is to prevent or limit the effect of, a major accident".

3.4.3.1 Matters Not Covered By SCR

The SCR regulations do not deal with protection of the marine environment from the consequences of a major accident. However, whilst environmental protection is not the main driver for HSC's general remit under HSWA, the requirements needed to reduce risks to the workforce will protect installations and reduce potential threat to the environment.

The SCR regulations do not require a safety case for offshore pipeline systems, but they do require each installation safety case to address all risks relating to risers or pipelines connected to the installation.

3.4.4 SELECTED EXTRACTS FROM DCR

The Design and Construction Regulations (DCR) complement other health and safety regulations in a number of areas. Specific interfaces are described under each regulation. DCR supports the general requirements on employers to ensure, as far as is reasonably practicable, the health and safety of their employees, and others that may be affected by their undertaking (HSWA Sections 2 and 3).

Some relevant extracts are included in this section below.

Additional Requirements

(DCR Regulation 12(1))

Ensures additional requirements of Schedule 1 are complied with.

(DCR Regulation 12(2))

Allows qualification of Schedule 1 (workplace requirements) in relation to people engaged in decommissioning, recognising that such activities would be temporary and would make full compliance with Schedule 1 impossible.

Decommissioning and Dismantlement

(DCR Regulation 10)

"… duty holder shall ensure … installation … is decommissioned and dismantled in such a way that … sufficient integrity …to enable such decommissioning and dismantlement … safely…"

Identification of hazards will contribute to demonstration required under SCR Schedule 5.

Design for Decommissioning

(DCR Regulation 5(1)(d))

"..duty holder shall ensure that … designs … are such that … installation … may be decommissioned and dismantled safely".

Fixed Installation
(DCR Regulation 2)
"… an installation other than a mobile installation".

Installation
(DCR Regulation 2)
Means an offshore installation within the meaning of MAR Regulation 3, except sub-paragraphs 3(a), 3(b), and 3(c)(ii). This means that any well connected to the installation, and any pipeline or equipment connected to the pipeline within 500 metres of the main structure of the installation, is excluded from the definition.

Installation Integrity
(DCR Regulation 4)
"..duty holder shall ensure that … installation at all times possesses such integrity as is reasonably practicable".

Integrity
(DCR Regulation 2)
"… structural soundness … strength …stability … buoyancy".

Planned Maintenance and Integrity
(DCR Regulation 8)
"… duty holder shall ensure … suitable arrangements … for maintaining … integrity …periodic assessment … remedial work…"

Verification of Safety-Critical Elements
(DCR Regulation 26)
Introduces requirements for the safety-critical elements of an installation to be verified by independent and competent persons. Schedule 2 amends SCR chiefly in relation to notification of well operations and introduces some amended definitions. Identification of safety-critical items should follow from identification of major accident hazards required by SCR Regulation 8.

3.4.5 SELECTED EXTRACTS FROM MAR

The Management and Administration Regulations (MAR) apply to fixed and mobile offshore installations, but not to subsea installations. They replace earlier prescriptive legislation on the management of offshore installations with more broadly based requirements setting out the objectives to be achieved, complementing other regulations dealing with the safe management of offshore installations. Regulation 4 sets out the places and activities to which MAR applies. All MAR regulations apply to installations while being dismantled.

Some relevant extracts are included in this section below:

Offshore Installation
(MAR Regulation 2)

"… a structure which is, or is to be, or has been used, while standing or stationed in relevant waters, or on the foreshore or other land intermittently covered with water … for … exploitation … exploration … storage of gas … conveyance … accommodation …and which is not an excepted structure".

When does an installation become an offshore installation?
If a mobile installation, when it enters relevant waters (i.e. UK waters) with intention of carrying out activity in Regulation 3, or if already in relevant waters (e.g. stacked) its intention becomes to carry out such activity in those waters

If a fixed installation, when its first significant part is towed out.

When does an installation cease to be an offshore installation?
When it ceases any activity specified in Regulation 3 and undertakes another activity (e.g. HLV contracted as flotel when it reverts to heavy lift activity).

If fixed, when dismantled and removed completely (removed pieces are not offshore installations), or if cut down below sea level (i.e. becomes subsea installation, although HSWA still applies). A toppled structure towed or carried back to shore .. for disposal will be similar to a new structure being towed out. Though an offshore installation, MAR will not apply.

If mobile, when it leaves the UKCS, or when it ceases an activity specified in Regulation 3 and stacks within Great Britain or territorial waters adjacent to Great Britain. A mobile that enters UK waters to stack or for repair or maintenance is not an offshore installation unless and until it prepares to carry out an activity in UK waters.

Offshore Installations include:

- Fixed Production Platforms
- Floating Production Platforms
- Floating Storage Units
- Mobile Offshore Drilling Units (MODUs)
- Flotels

The following are not classed as, or part of, Offshore Installations:

- HLVs
- DSVs
- Shuttle Tankers
- Well Service Vessels
- Stacked MODUs
- Subsea Installations
- Dredgers
- Wells not connected to an installation
- Survey Vessels
- Pipelaying Barges
- Pipelines more than 500m from main structure to which they are attached
- Structures permanently attached to dry land by bridges or walkways e.g. piers.

[Note: the Petroleum Act 1998 covers offshore installations, subsea installations and offshore pipelines.]

Installation in Transit from Station
(MAR Regulation 3)
Applies to installations being dismantled and installations in transit from their station (see Regulation 4 which excludes installations in transit)

Installation in Transit
(MAR Regulation 4(2))
"Regulations 6 to 21 shall not apply … to an offshore installation … in transit to or from a location, or when being manoeuvred at the location".

Unmanned Installation
(MAR *Regulation* 4(3))
"… nothing in Regulations 6 to 13 or 15 to 18 shall impose a duty in relation to an offshore installation while there are no persons aboard".

4. SCHEDULE OF DECOMMISSIONING IN THE NORTH SEA

4.1 OVERVIEW OF THE DECOMMISSIONING ISSUE

The offshore industry began in the Gulf of Mexico in 1947. Since then, the industry has designed, built and installed more than 6500 structures on the continental shelves of some 53 countries (3). The numbers of offshore installations around the world are around 4000 in the Gulf of Mexico, 1000 in Asia, 700 in the Middle East, 500 in Africa, 350 in South America and 500 in Europe. The seven basic types of offshore installation, with their approximate numbers as at May 1998, are as follows:

- Steel jacketed platform (shallow water < 75 metres) (6000)
- Concrete GBS (30)
- Steel GBS (3)
- FPS (100)
- Steel jacketed platform (deep water > 75 metres) (600)
- Compliant Tower (1)
- TLP (12)

No two structures are alike, as each individual installation is site-specific depending on the purpose of use, sea environment, location and many other factors. Hence, it is impossible to design a prescriptive decommissioning policy for all circumstances.

Although the North Sea contains less than 10% of the world total of offshore installations, decommissioning costs will be about 60% of the total because of the weight, complexity and severe environmental conditions. Removal costs have been estimated (3) for the US Gulf of Mexico at $5 billion (4000 structures), and for the North Sea of $12 to $15 billion (with 400 structures, only 10% of the Gulf of Mexico installation population, but three times the removal cost). The US accounts for about 200 large steel structures, whereas Norway and the UK have 50 each, India has 35, Malaysia and Peru have 20 each and the Congo has 18. Decommissioning of these large structures will be of concern to the technical community.

Since 1973, 100 to 150 small structures have been removed annually from the Gulf of Mexico. The owner / operator recommends a removal / disposal solution to the authorities, but the relevant state authorities make the final decision that the owner / operator must then implement. In the North Sea, the real removal effort is only now beginning.

In submitting a decommissioning recommendation, the operator must show that more than one option was considered. In more than 90% of cases, the decommissioning solution will generally be straightforward. However, the industry should be well prepared for all eventualities, learning from the experience of the Brent Spar, where the owner recommended a solution (deepsea disposal) which the authorities approved but public opinion intervened and eventually forced the operator to reconsider alternative solutions.

Although there was a strict and competent regulatory regime in place to control decommissioning of offshore structures prior to the Brent Spar incident, the incident brought the loud message to industry that decommissioning is a process, not just an engineering project. A technically and scientifically sound solution that complies with all regulations is not enough to secure public confidence and support. The industry must communicate openly with credible messages.

It can be seen from the distribution of offshore installations worldwide that decommissioning is a global issue. Most experience to date of decommissioning oil and gas installations is in the Gulf of Mexico, where around 1500 have been removed. All such installations were relatively small, with less than 10% of the total donated to the US Artificial Reef programme. To date, only 30 or so installations have been removed from the North Sea.

4.2 DECOMMISSIONED PLATFORMS IN THE NORTH SEA

As in the Gulf of Mexico, the majority of installations decommissioned to date in the North Sea are either small steel platforms, or floating or subsea installations. All (with the exception of Piper Alpha) have been totally removed to shore for recycling or re-use. There is limited experience to date of removal and disposal of large steel installations.

The following decommissioning activity has taken place in the various countries of the North Sea and North-East Atlantic [14].

4.2.1 INSTALLATIONS DECOMMISSIONED IN UK SECTOR

The first platform to be removed from the UK sector was the BP West Sole WE Platform, a small satellite installation 75km east of the Humber in 26 metres water depth. The deck weighed 180 tonnes, and the 4-leg jacket weighed 200 tonnes. The complete list of structures removed to date is as follows:

1985	West Sole WE (SNS steel platform), Thistle SALM (FSU)
1985	Beryl (SPM)
1988	Piper Alpha (SNS steel platform)
1990	Crawford (FPS + SS)
1992	Duncan (SS), Innes (SS)
1992	Blair (SS)

1993	Argyll (FPS+SS), Angus (FPS+SS), Forbes (SNS steel platform)
1994	Fulmar SALM (FSU)
1995	Staffa (SS), Brent Spar (FSU)
1996	Esmond/ Gordon (3 SNS steel platforms), Viking (4 SNS steel platforms), Emerald (FPS)
1997	Leman BK (SNS steel platform).

4.2.2 INSTALLATIONS DECOMMISSIONED IN NORWEGIAN SECTOR

The complete list of structures removed to date is as follows:

1996	NE Frigg (articulated column + SS)
1997	Odin (steel platform).

4.2.3 INSTALLATIONS DECOMMISSIONED IN DUTCH SECTOR

The first platform to be removed from the Dutch sector was the Wintershall K13D, a small satellite in 26 metres water depth. The cellar deck weighed 100 tonnes, the main deck weighed 770 tonnes, and the 4-leg jacket weighed 700 tonnes. The complete list of structures removed to date is as follows:

1988	Wintershall K13D (steel platform)
1989	Wintershall K13C (2 steel platforms)
1998	Kotter (2 steel platforms), Logger (2 steel platforms).

4.3 UKCS INSTALLATIONS AFFECTED BY OSPAR

Thirty-four large steel platforms in the UKCS no longer have the option of partial removal, as follows [15].

Field/ Platform	Operator	Decommissioning Date	Location	Type	Water Depth (m)	Jacket Weight (tonnes)
NW Hutton	Amoco	2000/ 2001 ‡	NNS	Oil	144	15587
Heather A	DNO	2001 ‡	NNS	Oil	143	16600
Clyde	Talisman	2004	CNS	Oil	81	12300
Forties FA	BP	2004/ 2008	CNS	Oil	106	12310
Forties FB	BP	2004/ 2008	CNS	Oil	122	14152
Forties FC	BP	2004/ 2008	CNS	Oil	127	14152
Forties FD	BP	2004/ 2008	CNS	Oil	120	14152
Thistle	BP	2004	NNS	Oil/ Gas	162	31396
Brent A	Shell	2005/ 2017	NNS	Oil/ Gas	140	14225
Miller	BP	2005	CNS	Oil/ Gas	102	17500
Eider	Shell	2005	NNS	Oil	158	17100
Murchison	Oryx	2005	NNS	Oil	156	44300
Saltire	Elf	2007	CNS	Oil	144	15000
Tiffany	Agip	2007	CNS	Oil	125	17500
Claymore A	Elf	2010	CNS	Oil	110	18000
Cormorant N	Shell	2010/ 2017	NNS	Oil	161	20052
Piper B	Elf	2010	CNS	Oil	144	22555
Tartan A	Texaco	2010	CNS	Oil	142	14500
Ninian	Oryx	2010	NNS	Oil	141	31500
Ninian Southern	Oryx	2010	NNS	Oil	141	43700
Tern	Shell	2010	NNS	Oil	166	20500
Fulmar A	Shell	2012	CNS	Oil	83	12400
Scott JD	Amerada Hess	2012	CNS	Oil/ Gas	140	16131
Scott JU	Amerada Hess	2012	CNS			
Nelson	Enterprise	2013	CNS			
Bruce	BP	2016	NNS			
Magnus	BP	2016	NNS	Oil	186	34400
Brae B	Marathon	2017	CNS	Oil/ Cond	100	18900
Brae South	Marathon	2017	CNS			
Alwyn North NAA	Total	2017	NNS	Oil	131	18500
Alwyn North NAB	Total	2017	NNS	Oil	131	14500
Alba	Chevron	2018	CNS	Oil	138	17000
Beryl	Mobil	2018	NNS	Oil	120	13250
Britannia	Chevron / Conoco	2033	CNS	Oil/ Gas	148	20000

‡ Note: the source data [15] is from a consultants review carried out in 1998 and decommissioning programmes have subsequently been deferred. An alternative source (also from 1998) also includes Morecambe CPP, Harding, Maureen A and Brae A within the same timeframe but omits Scott JU, Nelson, Bruce and Brae South.

5. INSTALLATION TYPES, CATEGORIES AND REMOVAL COSTS

Prior to the Government's accedence that the UK's international obligations on decommissioning would be governed principally by the OSPAR Convention, the DTI Oil and Gas Division commissioned a number of studies to provide background information and assist in an evaluation of the implications of adopting the OSPAR regime.

The studies included an independent technical review and analysis of the various methods for removing offshore topsides and support structures, together with cost estimates and cost sensitivities for decommissioning the UKCS platforms. UKCS platforms were categorised into four separate groups related to their weight and size as described below. Specific attention is drawn within the study to seven structures categorised as Very Heavy Steel (VHS) structures and forty-four Large Steel Jackets (LSJ) which are considered to be "difficult to remove". Over twenty of the VHS and LSJ installations are identified as "very difficult to completely remove". Some of the decommissioning scenarios evaluated in the study are not longer potential options under OSPAR Decision 98/3.

This section also describes the various types of jacket and topsides configurations that have been used in the North Sea. These configurations have altered over the years as lifting capacity increased and technology evolved.

5.1 JACKET CONFIGURATION

A major factor dictating the geometrical arrangement of steel jacket structures was the original installation method.

There were three main methods of jacket installation:

- Lift installed
- Barge launched
- Self floater.

5.1.1 LIFT INSTALLED

The jacket was transported offshore on a barge and lifted onto the seabed using a heavy lift vessel (HLV). Since the late 1980s, jackets weighing up to 10000 tonnes could be installed in this way.

5.1.2 BARGE LAUNCHED

The jacket was transported offshore on a special launch barge, launched into the water on its side and upended using ballasting, sometimes crane assisted. This method was used for most jackets before large HLVs were available. The method is still used for heavy deep-water platforms.

5.1.3 SELF FLOATER

A self-floating jacket was designed to incorporate its own buoyancy, allowing it to be floated offshore and upended by ballasting. This method of installation was used for some deep water jackets in the 1970s and early 1980s.

5.2 TOPSIDE CONFIGURATION

There are three basic types of topside module support depending on the size and the number of modules.

- Module Support Frame (MSF)
- Cellar deck
- Integrated deck

5.2.1 MODULE SUPPORT FRAME (MSF)

This is in one section for placing on 4-leg jackets or usually in two sections when on 8-leg jackets. The weight of an MSF would generally not exceed 2000 tonnes due to the lifting constraints at the time of installation.

5.2.2 CELLAR DECK

This is either in one or two sections similar to an MSF, with some utility equipment and piping, weighing between 2000 and 5000 tonnes.

5.2.3 INTEGRATED DECK

This can weigh up to 11000 tonnes, and includes process and utility equipment. It is placed directly on the jacket legs, and further large modules can be stacked on the integrated deck.

In addition to modules, other items lifted on are the flare stack, the drilling sub-structure, turbine exhaust stacks and link bridges.

5.3 INSTALLATION CATEGORIES

The four categories of UKCS offshore installation identified in the aforementioned study are described below.

5.3.1 CONCRETE AND STEEL GRAVITY BASE STRUCTURES (GBS)

There are 12 of these structures (refer Appendix A.1) in the UK sector of the North Sea. Ten are large concrete GBS with a substructure weight of between 150000 and 350000 tonnes. Maureen is a steel gravity structure. Ravenspurn North CPP has a concrete substructure weighing 38,500 tonnes in 43 metres of water. Special dispensation may be required for this structure.

5.3.2 VERY HEAVY STEEL JACKETS (VHS)

There are seven such platforms (refer Appendix A.2) with substructure weight in excess of 20000 tonnes. Two of these were installed as self-floating jackets, and the remaining five were barge-launched. All of these structures are considered to be *"very difficult to remove"* in the study report.

5.3.3 LARGE STEEL JACKETS (LSJ)

44 such structures (refer Appendix A.3) are located in water depths greater than 75 metres with jacket weights in excess of 4000 tonnes. 22 of the platforms are deemed to be *"difficult to remove"* in the study report.

5.3.4 SMALL STEEL PLATFORMS (SP)

The study identified 161 structures in this category.

5.4 JACKET AND TOPSIDES DECOMMISSIONING FACTORS

The methods and costs of decommissioning depend on factors related to the topsides and the support structure. The main factors for steel jackets and topsides facilities are described below.

5.4.1 STEEL JACKETS

Factors include:

- Jacket type
- Jacket weight
- Number of legs, diameter and thickness
- Water depth
- Number and size of piles

- Soil conditions and mudmats
- Number of wells.

5.4.2 TOPSIDES

Factors include:

- Number, maximum size and weight of modules
- Total topside weight
- Topside complexity (toxic compounds etc.)
- Type of module support frame (MSF) or integrated deck (ID)
- Number of drilling rigs on platform
- Accommodation capacity
- Size and number of flare support structures.
- Number of cranes.

5.5 HEAVY LIFT VESSELS

Three generations of heavy lift vessel (HLV) have been used for platform installation in the UKCS.

5.5.1 FIRST GENERATION HLV

The first generation (prior to 1979) was ship-shaped with a single crane at the stern of approximately 400 to 2000 tonnes capacity (e.g. Stanislav Yudin, DLB1601 and Four Tak). These were the only types of vessel available at the time.

5.5.2 SECOND GENERATION HLV

The second generation (from 1979) of HLV was a purpose-built semi-submersible type vessel with two cranes each capable of 2000 to 3000 tonnes, or capable of a tandem lift of the order of 6000 tonnes (e.g. Balder, Hermod, DB101). Balder and Hermod have been upgraded with cranes of 3000 to 4500 tonnes capacity, and are now capable of a tandem lift in excess of 6000 tonnes.

5.5.3 THIRD GENERATION HLV

The third generation of HLV is a purpose built very large semi-submersible crane vessel (VLSSCV) type commissioned in 1989, with two cranes each rated at 6000 tonnes or 12000 tonnes tandem lift capability (e.g. Thailfa, formerly DB102, and S7000, formerly the M7000).

5.5.4 OPERATIONAL LIMITS OF REMOVAL EQUIPMENT

The traditional view of a heavy lift offshore is of a topsides module weighing up to 8% of the lift vessel's displacement [(24)]. Cranes are usually able to rotate through 360 degrees, but some cranes are an integral part of the vessel and the vessel rotates as necessary. During decommissioning, the lifting operations will take place either within the 500-metre exclusion zone or at the place of reception onshore. Lifting at a quayside is within the sheltered confines of a harbour, and generally poses fewer problems. Crane vessels may have to stand away during the detonation of cutting explosives, but in the meantime the jacket must be prevented from falling into an irretrievable position. Cutting operations require careful planning together with the lifting and support services contractors.

In addition to the types of heavy lift vessel described above the following vessel types may also be involved in decommissioning and removal offshore lifting operations:

- Shear Leg Barge (SLB), with 500 to 1200 tonne capacity, using non-rotating A-frame masts
- Derrick Barge (DB), with 200 to 800 tonne capacity

The weight of the lifted item should always be carefully determined at the planning stage, but this may not always be possible accurately e.g. the pull needed to extract a pile. Even the smallest offshore platforms are the same height as Big Ben. There are limits on the weight of sections that can be safely lifted. During an actual lift, the theoretical lift capability will be significantly affected by safety and operational constraints, the size and structural integrity of the pieces to be lifted, vertical and horizontal clearances etc. It may be considered too risky to place the removed piece onto a heaving cargo barge, hence it will have to be placed onto the crane vessel deck. There are also limitations on the weight that can be lifted underwater when slings have to be attached below the sea surface. For example, when removing the 6200 tonne Odin jacket using the Saipem 7000 crane vessel with 14000 tonne lift capacity, the contractor decided that three major lifts were required, in addition to a number of lifts of minor sections. Anchoring requirements (e.g. proximity to other facilities, subsea wellheads, pipelines etc.) will also affect vessel positioning.

5.6 INSTALLATION DECOMMISSIONING COSTS

The study estimated decommissioning costs and cost sensitivities of removing the UKCS platforms. The assumptions regarding topsides and jackets are described below. The total estimated costs of removing all the platforms in the four installation categories identified in Section 5.3 are provided in the table below. Although the HSE is not concerned with costs per se, the study is indicative of the methods under consideration.

5.6.1 TOPSIDES REMOVAL ASSUMPTIONS

The study assumed that an integrated deck weighing up to 11000 tonnes and large modules up to 8000 tonnes could be lifted and placed on a barge by the third generation lift vessels. None such have yet been removed, but the study assumed that pre-engineering could resolve any associated technical problems.

It was also assumed for cost modeling purposes that all topsides facilities would be taken ashore for dismantling, with scrap value assumed to be zero. The location and method of placing facilities on shore depended on the removal method and the vessel. If piece small, maximum weight of each piece would not exceed 20 tonnes, with scrap lifted onto a supply boat. With modules on the barge, the barge draught limited the shore location. It was assumed that modules would be removed by a Mammoet-type trailer or lifted off by crane if the modules were small enough. The barges would require purpose–built grillages.

5.6.2 JACKET REMOVAL ASSUMPTIONS

It was assumed that small jackets in shallow water (less than 60 metres water depth) could be lifted as a single item and transferred to shore. Jackets located in water depths of less than 75 metres were assumed to be completely removed.

Larger jackets would be cut and removed in sections, with the number of sections depending on the type and size of the jacket, and on the water depth. Some difficult-to-remove platforms were assumed to have their bases left in situ because, prior to the OSPAR ruling, there was a 55 metre clearance requirement for shipping above the abandoned remains of offshore installations.

5.6.3 DECOMMISSIONING COSTS

The estimated costs of decommissioning UKCS installations as presented in the study are provided below. Shaded columns indicate options that are not now available because of OSPAR.

Category of Platform	Number of Platforms	Topsides [1] Removal Cost £ Billion	Removal to Bottle Tops £ Billion	Complete Jacket Removal £ Billion	Partial Jacket Removal £ Billion	Toppling Jacket £ Billion
GBS [2]	12	0.6	0	0	0	0
VHS	7	0.3	0.9	0.6	0.4	0.1
LSJ	44	1.5	2.6	1.5	1.2	0.7
SubTotal	**63**	**2.5**	**3.5**	**2.1**	**1.6**	**0.8**
SP	169	1.3	1.9	1.9	1.9	1.9
Total all categories	**232**	**3.8**	**5.4**	**4.0**	**3.5**	**2.7**
Total [3 & 4]	**232**	[5]	**9.2**	**7.8**	**7.3**	**6.5**

Notes:

1. Most topsides facilities are assumed to be removed as lifted modules. Piece small removal requires investigation related to each platform.
2. Removal costs are for the topsides facilities only on gravity based structures as they are assumed to be left in place.
3. Estimated costs exclude other types of offshore facilities including TLPs, FPSOs, jack-up production facilities, articulated loading buoys, subsea facilities, pipelines and loading buoys.
4. Removal of drill cuttings is excluded from the cost estimates.
5. Cost of topsides from GBS platforms is included in total costs.

6. THE DECOMMISSIONING PROCESS

6.1 INTRODUCTION

Even if an installation could be left in place, there would need to be some abandonment work done to remove harmful materials. With toppling and dumping options outlawed at the meeting of the OSPAR Commission in July 1998 (Decision 98/3), the decommissioning options remaining are described in this section. Under OSPAR, the concept of a waste hierarchy has been established where re-use is preferred over recycling (and, in time, over scrapping), and complete platform removal is the norm. The DTI's Guidance Notes [6] expand on this approach.

Decommissioning occurs when oil or gas production from a field is exhausted or when an installation reaches the end of its useful life.

For drilling and production installations, there are three principal stages:

- Cessation of production
- Plugging and abandonment (P&A) of wells and making them safe
- Removal and disposal of redundant facilities as appropriate

The owner / operator is required to prepare a Decommissioning Programme which identifies the decommissioning options, evaluates the technical feasibility, assesses the environmental and societal impacts, and minimises the risks to human health and safety. The operator makes a recommendation to the government but the government makes the final decision.

The principal method of small platform removal and that proposed for larger platforms would be to lift the topsides onto a HLV and then lift all or part of the jacket also using a HLV. Such operations are weather-dependant, implying a seasonal requirement competing with installation, which could have cost implications. In addition, the world HLV fleet is small, with some nearing the end of their working lives.

Over the next twenty-five years, it will be necessary to decommission 6000 platforms in 53 countries world-wide [1 and 17], from small single well structures in the Gulf of Mexico to the heavy deepwater structures in the North Sea and offshore California. A balance will be sought between health and safety, environmental, technological and economic factors. There will be some formidable technological and operational challenges, with worldwide costs of the order of between $20 and $40 billion. Although the North Sea contains less than 10% of the world total of offshore installations, decommissioning costs will be about 60% of the total because of the weight, complexity and environment. Although around 1500 platforms have been removed from the Gulf of

Mexico, only 30 or so have been decommissioned so far in the North Sea, and there no experience to date of removing large heavy platforms.

Decommissioning of offshore installations is subject to a hierarchy and tight network of international, regional and national regulations. Different conventions, laws and regulations address the two separate components of decommissioning, namely removal and disposal. Leaving a structure in place is considered disposal, whereas emplacement as an artificial reef is considered other use.

Decommissioning options for the substructure reduce to total removal (to shore for recycling or disposal as waste, deep water disposal, reuse or other uses), partial removal (to shore for recycling or disposal as waste, deep water disposal, reuse or other uses, emplacement or toppling on site), or leave in place. On the UKCS, under OSPAR Decision 98/3, disposal at sea or leaving wholly or partially in place can only ever be contemplated in 'exceptional circumstances' [(6)].

Topsides to date have generally been taken to shore for recycling or reuse.

In all cases, wells will have been plugged and abandoned and the facilities will have been made safe. These operations are well documented and proven procedures are in place. From a regulatory viewpoint, the removal requirements are fairly straightforward. There are technical feasibility, operational, cost, safety and environmental issues to be considered, particularly with concrete GBS and large deepwater steel structures. Well P&A operations in the UK are slow and costly, whereas techniques in the Gulf of Mexico are faster, and are consequently attracting growing interest from operators on the UKCS.

New 'single lift' technology such as Versatruss is being promoted, and has already been used for small topsides removal (1100 tonnes) in the Gulf of Mexico. This technology is still under development for topsides up to 11000 tonnes. The Offshore Shuttle [(17)] is another concept, scheduled to be available in the summer of 2001. This is currently being designed for lower-cost removal and transportation of jackets and topsides, and it is anticipated that it will be able to remove topsides weighing up to 25000 tonnes. However, there are safety issues associated with these new largely unproven technologies. A number of operators are supporting the further development and demonstration of some of these 'single lift' concepts through joint industry projects[(16 and 19)].

6.2 DECOMMISSIONING OPTION ASSESSMENT

The best decommissioning option will not always be the same solution for different special-interest groups. The principal spheres of special interest are the environmental, health and safety, financially interested and politically active groups. The DTI Guidance Notes (6) promote the need for a comparative assessment of decommissioning options in accordance with Annex 2 to OSPAR Decision 98/3, particularly for complex decommissioning scenarios. An earlier approach (18) utilised the Best Practicable Environmental Option (BPEO) model for assessing an abandonment strategy, where best practicable is examined from each of these spheres of interest.

In accordance with OSPAR Decision 98/3, the comparative assessment of decommissioning options should take account of, but not necessarily be restricted to:

- Technical and engineering aspects of the option, including re-use and recycling and the impacts associated with cleaning, or removing chemicals from, the installation while it is offshore.
- The timing of the decommissioning.
- Safety considerations associated with removal and disposal, taking into account methods for assessing health and safety at work.
- Impacts on the marine environment, including exposure of biota to contaminants associated with the installation, other biological impacts arising from physical effects, conflicts with the conservation of species, with the protection of their habitats, or with mariculture, and interference with other legitimate uses of the sea.
- Impacts on other environmental compartments, including emissions to the atmosphere, leaching to groundwater, discharges to surface fresh water and effects on the soil.
- Consumption of natural resources and energy associated with re-use or recycling.
- Other consequences to the physical environment which may be expected to result from the option.
- Impacts on amenities, the activities of communities and on future uses of the environment.

- Economic aspects.

The above aspects essentially encompass four assessment criteria:

- Safety to persons
- Technical feasibility
- Cost
- Environmental impact.

These assessment criteria are described briefly below.

6.2.1 SAFETY TO PERSONS

Safety to persons requires assessment of the risks of injury or death posed by the development and its alternatives.

This will require consideration of offshore safety and the risks associated with all marine activity, onshore safety and the risks to personnel arising from associated onshore work, residual risks to safety arising from the end point of the various disposal options, and the risks associated with deviation from the intended plan.

6.2.2 TECHNICAL FEASIBILITY

Technical feasibility requires an assessment of the likelihood of the proposed development being completed successfully, and the risks and consequences of deviations from the planned course of action.

This will depend on jacket weight, water depth, installation type, number of legs, number of piles, decommissioning date, presence of bridge-links, presence of integrated deck, topsides weight, total weight, number and size of modules, maximum module weight, presence of bottles, base length and breadth, presence of drill cuttings, presence of drilling template, feasibility of single vertical emplacement, presence and functioning of buoyancy aids, and number and size of storage tanks.

6.2.3 COST

The financial cost of the different possible courses of action must be estimated and compared.

The principal cost drivers for decommissioning will be total offshore and onshore man-hours required, support logistics, capacity of heavy-lift vessels, availability of vessels, the HLV and SSCV market, duration of lifting operations, transportation requirements, shore transfer/ retro-loading, engineering design and project management, volume of decommissioning contracts current at the time, public relations and media management, and opportunities for economies of scale.

6.2.4 ENVIRONMENTAL IMPACT

The relative environmental impacts of the different options, including the effects on other users of the sea, must be assessed.

This will require consideration of marine impacts, onshore effects, use of energy and release of carbon dioxide, cutting techniques used, movement of drill cuttings, deep sea disposal effects, artificial reefs, and recycling and reprocessing effects.

6.2.5 DRILL CUTTINGS

Drill cuttings are ground up rock fragments recovered during the drilling of wells into oil and gas reservoirs. Drilling mud is fluid circulated around the well to lubricate the drill bit, transport the cuttings to the surface and keep the hole from collapsing. When the drilling mud comes to the surface, the fluid is recovered and the cuttings are left as waste product. Drill cuttings consist primarily of inert rock chippings together with some adhering drilling mud. In most cases, the drilling mud is water-based but occasionally some are oil-based. Only minimal oil residues adhere to the cuttings. The discharge of oil-based mud is tightly controlled by OSPAR, with the oil content not to exceed 1% by weight since 1 January 1997 [25], but older installations were not subject to such stringent requirements.

Unless dispersed by tides and current action, such as in the shallower Southern North Sea waters, drill cuttings accumulate around the structure base, mostly within the area bounded by the structure's legs. Cuttings piles vary widely in size and composition which change with time, and they sometimes become densely compacted. Access may be difficult because of jacket legs and steel members, risers and conductors. The median height of a cuttings pile can vary from between five and seven metres. Monitoring has shown that the oil remains trapped within the pile and the effects of the cuttings are hence localised.

A joint industry project is being undertaken to explore options for accumulations around North Sea platforms, ranging from leaving the cuttings in-situ to total removal. The programme of work includes consideration of cuttings content / toxicity, environmental impact and natural degradation, bioremediation solutions, in-place covering, removal techniques, and onshore / offshore disposal. The programme was launched in 1998 by UKOOA, supported by the International Association of Oil and Gas Producers and in cooperation with OLF. Results of Phase 1 are now available; Phase 2 is scheduled for completion in 2001 [14].

6.3 DECOMMISSIONING OPTIONS AFTER OSPAR

Now that toppling in situ and disposal at deepwater sites is banned following the OSPAR ministerial agreement in July 1998, the remaining decommissioning options for topsides and jackets are described below.

Options for decommissioning are driven by environmental protection, cost, health and safety, available technology and politics. The infrastructure of NWECS represents investment of £150 billion in period 1965 to 1996. Potential existing decommissioning sites are all fabrication sites in UK, Norway, Sweden, Denmark, Holland and Germany. There are four basic classes of installation, namely, Fixed Platforms, Moored or Tethered Platforms, Pipelines and Subsea Structures. Fixed platforms (i.e. jackets and CGS structures) present greatest difficulty, while moored/ tethered structures will be relatively easy to remove.

6.3.1 TOPSIDES

The basic options are to either remove piece small (in pieces not exceeding 20 tonnes weight) or to remove piece large.

The topsides will either be modular packages of 500 to 3000 tonnes on MSFs, or Super Modular Packages (SMP) of 3000 to 5000 tonnes on Integrated Deck Structures up to 9500 tonnes. The former are generally found on older platforms, and the latter on the newer platforms that were installed after the arrival of VLSSCVs (since 1988). It is difficult to see a convincing argument for the seabed emplacement of any component of topsides, but this option is outlawed anyway under the provisions of OSPAR.

Removed items will then be taken ashore for recycling or reuse.

6.3.2 SUBSTRUCTURES

The basic options are to either totally remove the substructure (for jackets weighing less than 10000 tonnes), or to partially remove the substructure (for structures weighing in excess of 10000 tonnes). This may be achieved by either lifting the substructure out of the water, or if possible refloating the substructure.

For partial removal, only the 'footings' may possibly be left in place (see Section 3.3.1) and a minimum water clearance of 55 metres is required above any partially removed installation which does not project above the surface of the sea [(6)].

Removed items will then be taken onshore for scrap or refurbishment.

6.3.2.1 Jackets

Jackets in shallow water having dry weight up to about 5000 tonnes can be lift removed in a single piece after cutting of wells and piles. Some of the older first-generation deep water jackets weigh 15000 to 20000 tonnes, and will need to be cut and partially removed. Removal of a major jacket in its entirety could be achieved by 3 or 4 heavy lifts. Significant engineering problems have to be overcome concerning mudmat release, renewal of lift attachment points, load path determination etc. Reuse of fixed major platforms other than topsides will require investigation because each structure is unique, designed for a particular purpose and environment. API RP2A and the Draft ISO code for offshore structures both have specific provisions for reuse including inspection requirements and allowance for fatigue life utilisation. The HSE has recognized the need to understand the basis on which reuse could be justified, and lessons can be learned from Gulf of Mexico experience, particularly in the light of the persistently low oil price. Cast-steel nodes may have potential for reuse in new jacket structures not necessarily in European waters.

6.3.2.2 Concrete Gravity Sub-Structures (CGS or GBS)

These are fewer in number but are generally one or two orders of magnitude heavier than their depth equivalent steel jacket neighbours, presenting particularly difficult problems for decommissioning and removal. An associated MSF is very heavy, generally beyond the lift capacity of even the largest VLSSCV as a single unit. Questions arise concerning the technical practicality of deballasting, disengaging from soil penetration and structural integrity during these processes. The greatest environmental risk is associated with the possible release of residual oil, slops and sludge from storage cells, and a considerable cleaning-up effort will be required.

6.3.3 MOORED OR TETHERED STRUCTURES

These consist of TLPs, FPSs, spar buoys and articulated towers. All structures are vessel based and therefore possess buoyancy. The large FPSOs will be able to access relatively few sites for decommissioning or recommissioning i.e. those sites with major dry dock or graving dock facilities. The prospects for refit, reconditioning or re-engineering of FPS and FPSO vessels appear good, although they could be difficult to phase successfully.

6.3.4 SUBSEA STRUCTURES

These include drilling templates, production manifolds, christmas trees, wellheads, protective structures, subsea valve structures, riser base manifolds, pipeline crossing structures, anchor blocks, anchor chains, and risers. Subsea components such as wellheads and production manifolds could be re-used.

6.4 STAGES IN THE ABANDONMENT PROCESS

6.4.1 BASIC PROCESS

The basic process in decommissioning and abandonment of an offshore installation or pipeline is as follows [20]:

- Shut down of production and abandonment of wells
- Decommissioning of the process systems
- Isolation and closing of export/ import pipelines for decommissioning separately
- Shut down and decommissioning of the utility systems
- Phased shut down of the life support and safety systems
- Deconstruction, removal and disposal of the topside facilities
- Removal of substructure.

Whichever abandonment option is selected, it is a precondition that production is shut in and the wells abandoned, the risers disconnected after flushing through and cleaning the pipeline, and finally the process system is decommissioned, inventory materials removed and the platform left in a safe condition. Options then are what to do with the redundant facility.

6.4.2 STAGES IN THE ABANDONMENT PROCESS

Ten stages in the abandonment process have been identified [21]:

1. Plan

This is a crucial part of the process. It will involve setting out the strategy, philosophy, goals and objectives for the abandonment programme. It will also require identification of the relevant legislation, hazards, and cost drivers.

Potential problems must be communicated to top management, and communication with the responsible government departments is essential. The DTI, the Scottish Executive, the relevant local authority and the appropriate fishing authority must all be either advised or consulted. All interested parties and stakeholders who may have requirements to be met should be consulted.

The safety case for abandonment must be prepared and submitted to the HSE for approval at least six months and associated pipelines notified to HSE under PSR at least three months before any decommissioning activity commences. Such safety cases will require a risk-based approach to comply with the relevant regulations.

2. Survey

A detailed survey will establish inventories, estimate weights of equipment, prepare weight reports, determine the platform structural integrity and structural condition, ascertain the state of the seabed and the subsea structure, and establish the order of dismantling.

3. Provide Temporary Services

The level of dependency on, and requirement for, support vessels must be determined.

4. Isolate Pipelines, Flowlines and Wells

The sequence of well-plugging will be established, and all wells must then be plugged and abandoned. All associated pipelines and flowlines must be isolated for separate decommissioning.

5. Decommission

A method and sequence of topside equipment draining, cleaning and gas freeing will be established. The topsides must be made safe by removing or making safe harmful substances. Production platforms must have all hydrocarbons removed and all equipment cleaned and purged before modules and connections can be cut ready for topsides removal. The extent of the cleaning activity depends on the state of the equipment and whatever contaminants are present. If LSA scale, heavy oil, wax or toxic components are present, there will be an associated increase in cleaning costs. By comparison, gas components should be very easy to clean.

6. Remove the Topsides

The topsides will be removed by a combination of cutting and lifting.

7. Disconnect the Structure from the Seabed

This will involve pile cutting, abrasive water jetting, diamond wire cutting and possible use of explosives.

8. Divide the Underwater Structure for Lifting

This will involve cutting under water, severing the conductors and possible use of explosives.

9. Clear the Site

This will entail removal of material, and possible removal of the drill cuttings.

10. Dispose of the Arisings

Waste materials will be carefully disposed onshore in accordance with the applicable standards and regulations and industry best practice.

6.5 WELL ABANDONMENT

Some wells can be plugged and decommissioned during platform operation, and water injection can also be decommissioned during operation. Well plugging can be carried out by platform drilling facilities if these are available. If the original wells were drilled from a jack-up, then a jack-up will generally be needed to plug them. Experience in the US indicates that P&A can be carried out quickly without a jack-up, with average cost reduction of up to 20% over use of a rig. Once the wellheads and tubing are removed or plugged, the conductors are cut below the seabed and removed by drill rig. Platform cranes can be used to load small items onto a supply boat, and jack-up cranes can also be used if there is a jack-up in attendance. At a selected time, production will be stopped, production systems cleaned and made hydrocarbon-free ready for dismantling and cutting. Final wells will then be plugged, and tubing and caissons will be removed from the jacket.

6.6 PIPELINES

Pipeline safety, including abandonment, is the remit of the Land Division of HSE's Hazardous Installations Directorate (HID). It is recognised that OSD has overall responsibility for safety in the UKCS area, with the Land Division's Gas and Pipeline Group providing specific pipeline expertise to support OSD in discharging this responsibility. The Gas and Pipeline Group is also responsible for the implementation of the Pipeline Safety Regulations (34), and has the remit to review the provisions for pipeline decommissioning in Abandonment Safety Case submissions and safety issues associated with the Decommissioning Programmes for pipelines submitted to the DTI.

The technical options for pipelines are:

- Remove to surface, then shore.
- Bury by retrenching or by rock-dumping.
- Part remove.
- Leave in place.

A reverse lay process using a semi-submersible lay barge is an option.

Whilst pipelines are not covered by OSPAR Decision 98/3, they are covered by the Petroleum Act 1998 and a Decommissioning Programme must be submitted to the DTI. The DTI Guidance Notes (6) encompass pipeline decommissioning.

6.7 TOPSIDES REMOVAL

6.7.1 PIECE SMALL

Topsides were installed as a number of modules, lifted and stacked onto a deck located on the substructure. Older platforms had an MSF placed on top of the jacket legs forming a base for modules, which prior to 1979 did not exceed 2000 tonnes. As many as 30-40 modules were hooked-up offshore, as well as living quarters, flare boom, drilling sub-structure and drilling derricks. Removal will require decommissioning of the process and utilities systems, cutting all connections, installing lifting connections, lifting onto a barge by HLV and finally transport to shore.

Topsides will be removed in small pieces that can be lifted by platform cranes onto a supply boat, and hence there is no HLV requirement. However, at some stage, additional accommodation and lifting facilities would be required.

If there is sufficient accommodation, the crew can move onto the platform to cut up the facilities in a preplanned manner. Alternatively, a flotel may be required early on, and one will probably eventually be needed before essential services for life support are decommissioned. A HLV will be required when the platform cranes have to be removed, and to lift the remaining structure. The HLV may also be able to provide accommodation, in which case a flotel will not be needed.

6.7.1.1 Advantages

- A HLV is not needed until the cranes are removed.
- All material can be removed by supply boat.

6.7.1.2 Disadvantages

- A flotel will be needed if accommodation is not available.
- Topside equipment must be totally cleaned offshore before cutting can start.
- Dismantling takes a long time.
- There are a number of workforce safety issues e.g. multiple vessel trips to shore, large numbers of personnel involved, decommissioning of essential life support services, decommissioning crews lack of familiarity with installation etc.
- The removal rate depends on the deck area and the logistics of material processing.

6.7.2 SMALL MODULES

Older platforms have a large number of small modules due to the lift capacity that was available at the time of their installation. It is possible to remove these modules in the reverse order to their installation. However in most cases the original lifting attachments will have been removed and lifting contractors may devise alternative lifting schemes. The topsides facilities can be separated and lift padears fitted, with the modules lifted directly onto a barge. Once on the barge suitable sea fastenings will be required to restrain the modules for transportation to the shore disposal site. Dismantling can use platform accommodation initially, and then use the lift vessel accommodation. Selection of the lift vessel will depend on the lifting duty required for the substructure, and whether the topsides and jacket are to be removed in a single period.

6.7.2.1 Advantages

- A wide range of HLVs is available for module lifting.
- Modules only have to be separated for lifting.
- Modules can be lifted by one crane and stacked on a barge for transport to shore.

6.7.2.2 Disadvantages

- Lifting points on the modules must be reinstalled.
- Some equipment may have to be removed to obtain a suitable centre of gravity position.
- There is increased work associated with separation of the modules.
- There are more lifts for the lift vessel compared with platforms with larger modules.
- The flare may have to be removed in sections.
- There may be difficulty associated with handling items out of reach of the cranes.

6.7.3 LARGE MODULES

After 1979 with increased HLV capacity, module weights increased to up to 5000 tonnes to reduce costly and complex hook-up work offshore. The number of lifts decreased accordingly, reducing the period of HLV requirement. These were installed with second-generation crane barges, which had up to 6000 tonnes capacity. Such installations possess a few large modules, which can be lifted off in reverse order. An advantage compared with small module removal is the reduced separation effort between modules and between modules and the deck.

6.7.3.1 Advantages

- Small number of heavy lifts.
- Fewer modules have to be separated for lifting.

6.7.3.2 Disadvantages

- Lifting points on the modules must be reinstalled.
- Some equipment may have to be removed to obtain a suitable centre of gravity position.
- If a tandem lift is required for large modules, they must be loaded onto a barge, as they cannot be placed on the deck of the HLV.

6.7.4 INTEGRATED DECKS

When HLV capacity reached 10000 tonnes using a tandem lift, it was then possible to construct an integrated deck that incorporated most of the process and utility systems and controls. The integrated deck was lifted as a single module and placed directly onto the jacket legs. A few additional modules were generally added to complete the topsides. Removal of such integrated decks has not yet been demonstrated, but investigations indicate that removal could be carried out in waves not exceeding 2 metres. However, placing the integrated deck onto a floating barge from a floating HLV could be complex due to the relative motions.

6.7.4.1 Advantages

- The same lift vessel can be used for deck and jacket.
- There are few modules, therefore less time is required for module separation.

6.7.4.2 Disadvantages

- Lifting points on any modules and the integrated deck may need to be reinstalled.
- If a tandem lift is required for the deck, it must be loaded onto a barge and sea-fastened, as it cannot be placed on the deck of the HLV.
- All personnel must be off the installation prior to lift.

6.8 SUBSTRUCTURE REMOVAL

6.8.1 FULL REMOVAL

The jacket or substructure is completely removed from the site.

6.8.1.1 Problems

- Removal of the cuttings pile under the jacket (this could be up to 5 metres deep).
- Grouting of piles can create large weights on the pile clusters, and the actual weight may be uncertain at the time of lift.
- It is difficult to cut grouted piles due to their thickness and mixture of materials.

6.8.1.2 Advantages

- Full removal leaves the seabed clear.

6.8.1.3 Disadvantages

- It is difficult to position lifting slings and spreaders within the structure underwater, and such operations are likely to require divers.
- There will be significant cost associated with a large number of difficult cuts in the base section of the steel jacket.
- There will be risks to the large number of personnel involved in underwater and lifting operations.
- The cost of lifting the base section is a large proportion of the total removal cost.
- The weight of the lift may be uncertain once the structure is above sea level due to the potentially unknown quantity of trapped water.
- It is difficult to load and support odd shapes on a barge (e.g. to achieve all cuts accurately in a single plane).
- There will be a need to remove the cuttings and to wash out the seabed around the base in order to remove the base sections.
- There is the possibility that a large quantity of mud around pile clusters will have to be removed before lifting.

- Mudmats will have to be undermined in order to counter the suction effect in soft soils.

- Onshore, pile clusters will be difficult to dispose of because of the combination of steel, grout and marine growth.

6.8.2 REMOVAL TO FOOTINGS

Partial removal involves removing the jacket but leaving the ‘footings’ (see Section 3.3.1) and a minimum 55 metres of seawater clearance between the highest point of the ‘footings’ and LAT.

6.8.2.1 Problems

- A HLV is required for jackets with small modules.

6.8.2.2 Advantages

- The difficult base footing section is not removed.

- There is a saving in the cost of jacket removal due to leaving ‘footings’ in situ.

- The cuttings pile can be left undisturbed, thereby reducing pollution potential.

- There is a reduction in the number of cuts by leaving ‘footings’ in place.

6.8.2.3 Disadvantages

- The ‘footing’ section is left on the seabed.

7. REVIEW OF RESEARCH INTO DECOMMISSIONING OF FIXED OFFSHORE STRUCTURES

7.1 INTRODUCTION

In Section 1 the seven OSD research objectives within the Decommissioning Strategy Area were listed. A review of research into fixed installation decommissioning was carried out on behalf of HSE and the original findings are summarised in this section relative to each of the seven research objectives. BOMEL has reviewed each of these findings in the light of subsequent developments and BOMEL's independent experience.

7.2 HAZARDS AND RISK CONTROL MECHANISMS

The first research objective is:

"To identify and evaluate the main hazards and risk control mechanisms associated with decommissioning, dismantlement, removal of installations and deferred decommissioning"

- **Earlier Research Conclusion**

Research into generic hazards appeared complete and well summarised, easily usable by inspectors. The six month deadline for submitting the abandonment safety case prior to the decommissioning start date might limit the detail that could be provided that far in advance for certain parts of the decommissioning process, and it was felt that a deadline of three or four months might be more appropriate.

It was also concluded that research needs for health and safety of workers during decommissioning and removal of fixed offshore installations had been addressed, together with consideration of general risks associated with methods of abandonment. It was also felt that legislative requirements had been considered, with detailed investigation into abandonment stages and techniques.

- **BOMEL Comment**

New techniques already available or under development (e.g. Versatruss, Offshore Shuttle) introduce new risks that need to be adequately addressed. Similarly, the regulatory position has altered due to the OSPAR ruling. With the emphasis now changed from toppling of large steel structures in-situ to removal and on-shore disposal there will be many more safety critical operations involving personnel including underwater cutting, support from other vessels or buoyancy during cutting, lifting, placement on barges, sea-fastening and transportation. These operations will involve significant numbers of people for durations which will involve greater weather related risks. This raises questions related to planning and uncertainly both in the environmental conditions during the removal operations and in the knowledge of the design details and current condition of the topsides and support structures to be removed.

7.3 LESSONS FROM GULF OF MEXICO AND ELSEWHERE

The second research objective is:

"To establish with industry the health and safety lessons learnt from the removal of installations in the Gulf of Mexico and other offshore regimes"

- **Earlier Research Conclusion**

Due to the size of the structures, usually in water depths of less than 50 metres, it was concluded that there were limited lessons to be learnt from the Gulf of Mexico. Research and legislation found it viable to use steel jackets to form artificial reefs in designated parts of the Gulf of Mexico, but it was felt that this option would be unlikely in the UK.

- **BOMEL Comment**

Experience from the Gulf of Mexico will have application in the UKCS, particularly in the Southern North Sea. Experience in the use of explosives, platform reuse and faster P&A techniques are already attracting interest from the UK, and will be likely to have UKCS applications. Corporate experience (not always good) will be likely to be transferred within organisations with operations in both the Gulf and the UKCS.

7.4 TOPPLING OF JACKETS

The third research objective is:

"To establish with industry the technology for toppling of jacket structures and the implications for risk control, and to validate associated software tools"

- **Earlier Research Conclusion**

Generic BPEO analysis suggested that full removal and disposal onshore of all but 37 (out of 300) North Sea steel jacket structures was the best environmental option. The process of toppling suggests that it could be analysed, but the process might require some effort to enable ease of use by inspectors.

- **BOMEL Comment**

Toppling is now not an option following the UK's commitment to the OSPAR Convention. A significant part of the toppling research effort was directed to the effects and effectiveness of underwater cutting using explosives and this work has wider value as an option for cutting during lift assisted removal.

7.5 REFLOATING CONCRETE PLATFORMS

The fourth research objective is:

"To establish with industry the technical criteria and the implications for risk control in the re-floating of concrete gravity-based platforms"

- **Earlier Research Conclusion**

Research concluded that re-floating of some types of concrete structures had been substantially analysed. Disposal of concrete structures would require further work, particularly if the platform could not be re-floated. Cutting of the concrete structure needed to be addressed. Research indicated that some concrete platforms could be re-floated. Disposal by scuttling was seen as the best option. General BPEO analysis suggested that concrete platforms should have their topsides removed and the remaining structure should be abandoned in situ.

There was emphasis on three aspects of re-floating, namely:

- Breaking out from the soil using buoyancy, water injection beneath the base and removal of the soil around the base perimeter.
- Floating stability immediately after breakout allowing for uncertainties in the platform weight and adhering soil.
- Practical engineering methods of re-floating.

- **BOMEL Comment**

The HSE needs to be involved in arguing the case for safe decommissioning and disposal of offshore installations. There are likely to be instances where the safest option will be leaving the installation in place. Further research is required into the design and functioning of floatation systems and in managing the uncertainties associated with refloating.

Consideration needs to be given to the risks associated with in-situ abandonment and responsibilities for managing these risks in the long term following completion of the duty holder's interests and, possibly, disappearance of the duty holder altogether.

7.6 EMERGENCY RESPONSE ARRANGEMENTS

The fifth research objective is:

"To investigate the implications to emergency response arrangements of decommissioning and dismantlement"

- **Earlier Research Conclusion**

Research concluded that the guidelines for evacuation, escape and rescue (EER) arrangements were well covered and summarised. It was felt that EER implications of decommissioning and removal could be controlled provided a good quality hazard management system was in place and implemented from planning through to complete removal.

- **BOMEL Comment**

HSE needs to consider how to evaluate the safety of temporary conditions, and how to handle a disaster under these circumstances. Recent experience with failure of marine heavy lift equipment in the Gulf of Mexico indicates that further research and investigation will be required to ensure that the risks and hazards associated with such temporary conditions are controlled and managed to as low a level as is reasonably practicable.

7.7 CUTTING AND EXPLOSIVES

The sixth research objective is:

"To establish the reliability of cutting techniques, particularly using explosives, and the factors influencing safe standoff distances and contingency plans"

- **Earlier Research Conclusion**

The report concluded that thorough research and legislation exists on the use of explosives underwater, suggesting that most related health and safety issues had been addressed.

- **BOMEL Comment**

The main types of cutting are erosive, mechanical, thermal, explosive and electrochemical. Abrasive water jetting has been found unsuitable for some reinforced piles. The US MMS would disagree that sufficient research has been carried out into shock waves caused by explosives, and it has concerns on the effects of explosives on marine life.

Now that toppling is no longer an option, external support to the jacket structure will have to be provided during cutting operations. This support is likely to involve manned lift vessels and/or externally attached buoyancy and therefore the effect of explosion shock waves and gas bubbles on such equipment will be of even greater concern and criticality.

On Viking, the water jets failed necessitating the intervention of divers, indicating that research is still required into the probability of failure of such systems. Cutting of heavy-walled tubulars is still a research area.

7.8 HEAVY LIFT OPERATIONS

The seventh research objective is:

"To appraise heavy lifting operations and their risk implications for the removal of installations"

- **Earlier Research Conclusion**

Earlier research concluded that safety issues associated with heavy lifting operations had been well addressed and summarised. Further work might be necessary into time-tabling of platform removal in order to ensure the availability of heavy lifting gear and heavy crane capacity when required. The previous research work summarised the variables to be considered when performing heavy lifting, namely, vessel type, crane type or manner of lifting, item to be lifted, size by mass or dimension, and location of event.

- **BOMEL Comment**

Heavy lifting presents a major area for safety hazards. Historically there have been some notable failures during heavy lift operations which have had the advantage of use of purpose designed lifting arrangements fully integrated into the design. In many cases these lifting arrangements either will not be possible to reuse or will be expensive to reinstate and therefore lifting contractors may be tempted to use less well planned, engineered and constructed methods (to take short cuts). Furthermore there may be considerable uncertainty associated with heavy lifting due to lack of availability of original design and construction information, changes made to the facilities and structure during their operational life and lack of knowledge on the current condition and structural integrity.

Clearly the reinstatement of lifting attachments both above and below water is an area for development. This could benefit from the sub-sea repairs technologies which have achieved high reliability in adverse conditions.

7.9 CONCLUSION FROM HSE RESEARCH

The earlier review concluded that most of the decommissioning health and safety issues have been addressed. BOMEL does not agree that this is a realistic assessment of the current position.

There have been several significant changes to the regulatory position since the earlier review was undertaken in 1995, and some of the larger installations are for the first time approaching their decommissioning date. Research is still required into many of the areas mentioned above, and new technologies presenting new risks continue to emerge. Transfer of experience from other areas in the world, non-linear analytical techniques, explosives and cutting techniques, safety arguments for leaving installations in place, safety in temporary conditions and heavy lifting operations all have major uncertainties which need to be addressed.

7.10 OTHER RELEVANT DECOMMISSIONING RESEARCH

7.10.1 TYPES OF STUDIES CARRIED OUT TO DATE

Three main types of decommissioning studies have been carried out to date [23]:

- **Platform Specific Studies**

Very few of these have been carried out to date and they are not generally available in the public domain. However, they highlight the fact that removal is not simply the reverse of the installation process, as the structure may have been altered, the load distribution may have changed, marine growth will have accumulated and the condition of the structure will have deteriorated. The largest platform removed to date was Odin in Norwegian waters.

- **Technology Development Studies**

A number of joint industry studies have been conducted over the years concerning platform decommissioning, addressing the following topics:

  - Underwater cutting techniques
  - Buoyancy aids / systems for re-floating
  - Toppling technology
  - Stability of disposal remains and potential movement of debris when toppled or placed on the seabed.
  - Re-floating concrete structures
  - Reuse

- ‘Single lift’ vessels
- Drill cuttings

- **Generic Studies**

These have ranged from detailed analysis to short summary technical papers and they have mainly been concerned with such areas as environment, comparative decommissioning option assessment, energy use and costs.

- **Department of Energy Pipeline Abandonment Study**

A summary report was published as OTH 97 535.

7.10.2 ODIN DECOMMISSIONING

The operator recommended that the deck and modules be taken onshore for scrapping, re-use or recycling, and that the jacket be toppled in place as an artificial reef. However, the Norwegian authorities decided that the entire platform should be removed and taken onshore for reuse, recycling or scrapping. The topsides were removed in late 1996, the upper part of the jacket was removed in February 1997, and the lower part of the jacket was removed in July 1997.

The main lessons learned can be summarised as follows:

- Plugging and abandoning (P&A) the wells proved more work intensive than expected
- The existing operations organisation proved effective
- Use of the Saipem 7000 speeded up the operation, thereby reducing the length of exposure of personnel to safety risks
- Underwater cutting equipment testing was underestimated, leading to downtime offshore
- Dialogue with the relevant authorities and stakeholders went well
- The all-inclusive contracting concept worked well avoiding potentially complicated interface issues.

7.10.3 GULF OF MEXICO CASE STUDIES

The average useful life of a Gulf of Mexico field is typically 25 years. The first documented removal was in 1973. Most decommissioned production systems have been either single wellheads or small steel-jacketed platforms. Removal costs vary widely depending on type, age, and condition as well as on water depth and seafloor composition.

In the Gulf of Mexico, of the 1500 or so installations that have been decommissioned (out of a current inventory of around 4500), reuse has been considered in two ways:

- First, can part or all of the platform be reused for other oil and gas activities? There are many examples where items of equipment or the complete topsides modules have been reused. Similarly jackets have been removed, cut to shape, equipped with additional foundation connections and relocated.

- Second, is there an alternative use for a decommissioned structure? At the initiative of fishing interests, the steel lattice of the jacket can be emplaced as an artificial reef to enhance fish stocks. Around 100 jackets have been used so far in this way.

The number of platforms being decommissioned each year is now starting to exceed the number of those installed. Decommissioning is now moving into deeper water and involving heavier installations.

7.10.3.1 Regulatory Position and Arrangements

There are three main federal agencies regulating oil and gas E&P, namely the Minerals Management Service (MMS) of the Department of the Interior, the US Coast Guard and the Environmental Protection Agency (EPA). There are also numerous other regulations with which an operator must comply. MMS regulations focus on safety and the environmental impact of exploration, drilling, completion, workover and production activities.

When it intends to relinquish a lease, the operator must notify the MMS, the Corps of Engineers, the Coast Guard and EPA. The surety bonds posted for leasing, exploring and producing are intended to cover the abandonment costs. The MMS can also require a supplementary bond. Legal requirements are open to flexible interpretation, but the Gulf is subject to the same international regulations such as the Geneva Convention and IMO regulations as everywhere else.

The operator submits an advance notice to the MMS listing the responsible party for procedure, identifying the structure to be removed, describing the structure, giving the reasons for its removal and describing the removal method. Once the necessary permits are secured, the operator will probably contract out some of abandonment tasks.

In the Gulf of Mexico, there is a well-defined process for decommissioning which places high emphasis on planning and preparation. Procedures involved include:

- Shutting down operations, disconnecting the facilities, removing contaminates, and making the structure safe
- Plugging and abandoning the wells
- Modifying and strengthening the deck and other facilities to allow lifting
- Removing and disposing of the facilities

- Removing and disposing of the deck
- Severing the piles and conductors
- Removing and disposing of the substructure
- Trawling for debris
- Final survey and clean-up.

There is also a Safety and Environmental Management Program (SEMP) which is currently subject to voluntary implementation, but the voluntary element may be made compulsory unless the quality of operators' plans that have been submitted to date improve. Studies carried out by the MMS in 1996 to monitor operators' SEMP plans concluded that the plans were inadequate and unsatisfactory.

The most frequently used cutting techniques in the GOM are explosives (67% of time). Explosive cutting techniques used include bulk explosive, configured bulk charges, shaped charges, and shock wave focusing charges. Explosives need to be made smaller and more efficient. The MMS gives permits for use of explosives, but they believe that far bigger quantities of explosive are actually used offshore than is permitted. Non-explosive cutting methods include mechanical, abrasive, diver, hydraulic shears, and diamond wire cutters. ROVs are being tested to replace dangerous activities currently performed by divers.

7.10.3.2 Conclusions From Gulf of Mexico Case Studies

The principal conclusions from Gulf of Mexico decommissioning experience are:

- Further study is required to understand the effects of explosives on marine life.
- Shock wave focusing techniques need to be developed.
- Operators need to provide contractors with more opportunity for test application of techniques to improve reliability in cutting and deployment systems.
- The emphasis on environmental impact and protection of marine life should be kept in balance with human safety issues.
- Further research is required to develop new technologies for installation removal, particularly for the larger jackets and integrated decks.

There is controversy over the use of explosives because of fish populations around platforms, and potential harm to sea turtles. However, the use of explosives incurs the least cost for removal in shallow water, followed by abrasive cut, mechanical cut and diver cut. Other demolition technologies under study include laser cutting, pyrotechnic cutting, cryogenics, chemical cutters, cutting with ROVs, bubble curtains to attenuate blast pressure, acoustic devices to keep fish away from platforms, and incorporation into new platform designs of easier ways to remove the structure.

Because of the extensive pipeline infrastructure in the Gulf, no production structures up to the mid-1990s were used for oil storage, and hence these are environmentally clean. They can be scrapped, refurbished, toppled (still an option in the Gulf) or used in artificial reefs.

Decks can often be recycled, but jackets are depth-specific. Jackets of older rigs do not meet new legislation strength requirements. Structures installed in the 1950s and 1960s will not meet current structural integrity criteria, and 90% of removed platforms end up as scrap metal. Artificial reefs are attractive to the oil industry as the owner is subsequently relieved of further responsibility once the donated structure is correctly positioned on the seafloor. However, artificial reefs are not without drawbacks; they need to be placed far from the shore, possibly inaccessible to sports fishermen; the reef site may be further from the rig site than the shore; the size, towing distance and water depth will help determine whether it is more cost-effective to donate or scrap. The operator pays the state for being allowed to abandon the structure as a reef, and the finance generates social benefits such as improved education and healthcare.

Chevron will be decommissioning some large structures in the Santa Barbara Channel in June 2000, in water depths of from 320 to 740 feet, and jackets weighing 7000 to 21000 tons. The topsides are all modular weighing from 10000 to 16000 tons. The US West Coast conditions (platform size, water depth and environmental concerns) are very similar to the North Sea. Much should be learned from the decommissioning and abandonment of these structures.

8. DECOMMISSIONING ISSUES IDENTIFIED

8.1 INTRODUCTION

Much of the earlier research and literature reviews were carried out under a different regulatory regime and pre OSPAR and therefore were heavily influenced by overseas (Gulf of Mexico) experience and the expectation that the deep water structures and heavy steel structures would be abandoned in-situ by toppling or emplacement. Clearly this is no longer the case and future emphasis needs to concentrate on removal of all but the ‘footings’ of steel structures (see Section 3.3.1).

Therefore earlier categorisations of issues such as that used in Section 7 are not very helpful in devising a topic strategy to meet future needs. In the section after this (Section 9 – Topic Strategy Recommendations) specific recommendations are made to address each of the principal Decommissioning Strategy objectives. In this Section 8 the issues identified from the reviews of Sections 3 to 7 are drawn out under the following headings:

- Strategic issues
- Safety management issues
- Technical issues associated with each principal phase of the decommissioning and abandonment process.

These issues need to be considered and addressed in order to develop an appropriate HSE decommissioning strategy.

8.2 STRATEGIC ISSUES

This section covers decommissioning issues which are of interest to a wide range of stakeholders, which go beyond HSE-OSD’s remit or which also involve other regulators or government departments. Issues are identified and discussed below under the following headings:

- Balance between safety, environment, commercial risk and cost
- Public perception
- OSPAR implications
- Responsibilities for safety between regulators
- Residual liabilities and future responsibilities
- Regulations
- Reuse, recycling, onshore disposal

- Experience, including overseas
- Workforce participation
- UK opportunities.

8.2.1 BALANCE BETWEEN SAFETY, ENVIRONMENT, COMMERCIAL RISK AND COST

The wider debate on decommissioning has been dominated by environmental considerations with almost no recognition of the significant increase in risk to human safety brought about by the UK's acceptance of OSPAR Decision 98/3.

Recent studies [25] on eight offshore installation decommissioning projects, all of which returned the topsides to shore, showed that risks to safety were considered to be higher for complete removal compared to toppling and partial removal options, mainly because of exposure of the workforce to offshore hazards. Ranking risks shows toppling and partial removal to be closely similar, while, for total removal, risks are greater when the jacket is cut up into sections for transportation to shore.

The general trend highlighted was unsurprising, namely that minimising the amount of offshore work would result in the lowest risks to personnel safety. The long term risks to navigation associated with partial removal were considered to be relatively insignificant compared to the decommissioning risks. The study concluded that risks to safety were approximately 50% higher for total removal to shore compared with the partial removal options. Minimising offshore work is therefore seen as the key factor to lowering risks.

The different decommissioning options and methods available appear to have similar environmental effects but significant differences in safety and cost. Comparative assessment [6] provides a procedure to decide between alternative decommissioning options although it is not clear how safety issues can be weighed against environmental and commercial risks and costs.

There may be conflict between the environmental issues and maintaining risks and hazards to levels as low as reasonably practicable (ALARP). Environmental issues should not be allowed to overwhelm the safety issues, but OSPAR has gone down the environmental rather than the safety route.

8.2.2 PUBLIC PERCEPTION

The public is generally unaware of the safety issues associated with decommissioning, and complex technical issues and concepts such as ALARP are difficult to communicate effectively. HSE will need to consider how to address the issue of safety in relation to the public's general awareness of the environmental issues, and also how an effective case can be presented to all stakeholders. When operators suggest that the large platforms constitute a significant risk if decommissioned, the public tends to disbelieve this and assume that the operator is attempting to save money or avoid its responsibilities.

For example, there are some very difficult and possibly insurmountable technical issues associated with concrete gravity base structures (GBSs), of which there are twenty-six in the North Sea. These are located in up to 300 metres of water and weigh from 200000 to 1000000 tonnes. There are serious doubts over the capability to refloat any of these concrete GBSs with a level of operating risk commensurate with accepted levels for offshore operations. Also, only a small amount of residual oil is likely to remain within a concrete structure after oil removal and cleaning, but further research should be undertaken to reduce uncertainties in the assessment of residual oil and to improve public perception.

If HSE were to engage in the debate and back some of these safety assessments, and say publicly that the risks associated with removal of certain installations were intolerable, the public and other interested parties would be better informed and would be more likely to be convinced.

8.2.3 OSPAR IMPLICATIONS

The UK agreement to OSPAR clarifies the position concerning deepsea disposal and toppling of offshore installations, and attention can now be directed towards implementation of the agreement. Now that for practical purposes, all except a few installations will be removed, attention can be redirected to how to do this most efficiently, how to deal with the opportunities rather than how to avoid the problems, the 'how' rather than the 'whether'.

The OSPAR Agreement raises significant safety implications associated with decommissioning as it is primarily concerned with the environment. Safety concerns could still lead to a case for partial removal for individual installations under the 'exceptional and unforeseen' provision. The HSE and the operators' representatives have a common interest in presenting the safety issues more effectively and in a more co-ordinated manner. HSE should work closely with UKOOA, among others, to develop an appropriate strategy.

After OSPAR, the first operator to propose leaving footings in place for one of the 41 UKCS platforms weighing more than 10000 tonnes faces a potential challenge, as does the first operator to propose leaving in place an installation due to 'exceptional and unforeseen circumstances' or from some other cause.

Although not presently covered by OSPAR, HSE should promote an industry approach to safe pipeline decommissioning methods.

8.2.4 RESPONSIBILITIES FOR SAFETY BETWEEN HSE AND OTHER REGULATORS

HSE OSD responsibilities for regulating offshore safety are principally concerned with safety on offshore installations. In decommissioning, when large sections are being lifted, transported away from the installation site and disposed of on-shore, other parts of the HSE (e.g. the Field Operations Directorate) will have responsibilities for the on-shore safety aspects. During transportation between the installation site and shore presumably the MCA would also have responsibilities. The interfaces between these responsibilities should be clear both between regulators and to other stakeholders.

8.2.5 RESIDUAL LIABILITIES AND FUTURE RESPONSIBILITIES

In the UK, residual liability remains with the installation owner's company in perpetuity. In the DTI Guidance Notes [(6)], it is recognized that provision needs to be made to ensure that there continues to be someone with liability for the remains of the installation (or pipelines) if the company ceases to exist. The industry is considering whether it might be possible to make appropriate insurance-based arrangements to address residual liability. By contrast, in Norway, the state may take over liability. The responsible party must be identified as they are liable for maintaining aids to navigation (if deemed necessary), for monitoring the condition of the remaining material, and they will also be liable for damage caused by any remaining parts.

8.2.6 REGULATIONS

No specific issues concerning regulations emerged from the literature. However the work involved in assembling Section 3 of this report which outlines global, regional (i.e. European) and national regulations was not insignificant and there is a need to maintain an understanding of all the regulations which may affect decommissioning activities both for HSE's and other stakeholders' information.

8.2.7 REUSE, RECYCLING AND ONSHORE DISPOSAL

Each oil and gas installation is unique, designed and built for a particular location, water depth and environmental conditions, and subject to the technology available at the time of design, construction and installation. Reuse of such installations has to date been limited, with the exception of topside modules and equipment items.

However, a persistently low oil price is likely to increase the push for reuse of redundant and decommissioned offshore installations. Reuse of redundant offshore installations is already attracting increased attention, and there is a history of reuse in the Gulf of Mexico and elsewhere. In general, reuse will have greater applicability to topsides, but a low oil price will prompt operators to consider refurbishment and reuse of jackets together with other offshore installation components.

The HSE will need to establish its position on what integrity requirements would be appropriate for reuse, possibly modelled on the assessment within API RP2A Section 17, with inspection possibly based on API RP2A Section 18.

Although dismantling and removal of large platforms will consume huge amounts of energy that could negate perceived benefits, recent studies suggest that energy use does not play a major role in the decommissioning process. However, energy use in a specific decommissioning study would be more precisely calculable. This will not be an issue for HSE, but it may help explain why operators recommend a particular decommissioning option.

Decommissioning involves a high level of plant and materials recovery, which can be included in the oilfield's economic model. These elements of decommissioning require reverse supply chain management, involving appropriate phasing in order to generate cash flow, aimed at target markets for recycled material, etc. Recovered items will include:

- Hazardous waste e.g. LSA Scale, heavy metal sludge, PCB Fluids, halon gases
- Valuable metals e.g. titanium, stainless steel, cunifer, monel, copper (cable)
- Reconditionable plant e.g. prime movers, rotating equipment, injection pumps, compressors, gas turbines, alternators, MV/HV transformers
- Bulk steel.

8.2.8 LEARNING FROM EXPERIENCE INCLUDING THAT FROM OVERSEAS

It is understood that the US MMS perceives limited take up by the UK of experience gained to date in the Gulf of Mexico, even though 1500 structures have been removed since 1973. This has now reached the point where more installations are being removed than installed. Such extensive experience is likely to prove useful, particularly in the shallower waters of the Southern North Sea, especially as the US is now moving to decommission larger structures in deeper waters [(15)].

Although Gulf of Mexico experience thus far has been limited to smaller installations, many structures have been removed to date, and there is considerable experience of all aspects of decommissioning including removal, disposal, recycling and re-use, together with the use of a number of innovative techniques. Gulf operators and contractors will also be involved in North Sea decommissioning, and their corporate experience may be of benefit for application in the UKCS.

HSE should engage in dialogue with their US counterparts at MMS to discuss how the Gulf of Mexico experience might be more widely publicised and applied to UKCS installations.

It is important that a balanced view is obtained of Gulf of Mexico experience by obtaining experience both from regulators (MMS) as well as operators and contractors. Few reports of safety or technical problems emerge into the public domain although problems are known to have occurred in the introduction of new technology, with lifting operations and with the use of explosives.

The largest platform removed to date has been Odin from the Norwegian sector in 1997, with a substructure of 6200 tonnes and topsides of 7600 tonnes. Individual modules were in the 1500 tonne range (compare with Northern North Sea structures with topsides in excess of 20000 tonnes, individual modules up to 10000 tonnes and substructures well over 10000 tonnes).

Opinions change and until some of the larger installations are removed, many current views are based on theory rather than practice.

8.2.9 WORKFORCE PARTICIPATION

Decommissioning operations require a large number of specialist contractors and their personnel to complete the decommissioning process both onshore and offshore. Many of the decommissioning crews offshore will be unfamiliar with installations and safety culture, which increases risks to themselves and to other personnel on board.

Experience reported from recent decommissioning projects showed that the most serious safety hazard was the involvement of a workforce which was unfamiliar with the installation and with the appropriate procedures.

Hence, training of decommissioning crews and fostering a safety culture are identified as vital safety issues. Regular communication is vitally important between the various personnel from the contracting organisations and the HSE at all times and during all phases, but especially as the installation is being progressively decommissioned. Coherence of the HSE safety message in these situations is a prerequisite.

8.2.10 UK OPPORTUNITIES

The UK offshore industry has achieved considerable success in areas outside European waters as a result of the experience gained in the North Sea. Part of this experience derives from the regulatory regime which, through its goal setting approach, may be regarded as more challenging. However many countries' regulations are moving in a similar direction and therefore UK organisations with this experience can benefit. Furthermore with a strategic objective of facilitating industry guidance and engaging in research activity to do this a by-product is the development of expertise in those (UK) organisations involved in the work.

8.3 SAFETY MANAGEMENT ISSUES

This section covers issues under the broad category of safety management including the processes for identification of hazards and management of risks, the requirements to plan and the arrangements to develop and review the safety case, roles and responsibilities, EER and contingency planning. These items are covered under the following headings:

- Hazards and risks
- The Abandonment Safety Case
- Safety Management Systems
- Responsibilities
- Review and audit
- EER
- Specific safety concerns

8.3.1 HAZARDS AND RISKS

The key to safe decommissioning, dismantling and disposal of offshore installations and pipelines will lie in proper assessment of the risks, and by observing safe systems of work. Many hazards and appropriate risk control measures associated with the decommissioning, dismantling and disposal of offshore installations are similar to those arising from construction or maintenance operations carried out both on and off shore.

There has been little dismantling or decommissioning to date in UK waters, hence there is little risk data available. Hazard identification involves identifying substances, objects or processes with the potential to cause harm. The presence of a major hazard does not necessarily imply a high risk, especially if the hazard is properly managed, but frequency and consequence need to be considered. The HSE definition of risk [26] is the probability that a specified undesirable event will occur in a specified period or as a result of a specified situation.

Generic hazardous operations include:

- Well plugging and abandonment
- Cutting of conductors and appurtenances
- Disconnecting, purging and sealing pipelines and risers
- Removal of pipelines, risers and associated subsea structures
- Removal of platform inventory
- Making process trains safe
- Final shutdown
- Dismantling of topsides
- Dismantling and removal of jacket
- Complete removal
- Loading to means of transport and fastening down
- Unloading from means of transport
- Disposal.

Some of the more significant hazards are described below which can arise during decommissioning, dismantling and disposal of offshore installations.

- **Hazards arising during offshore installation decommissioning**
  - Installations must be isolated from sources of hydrocarbons.
  - Wells must be plugged and sealed.
  - Pipelines must be isolated and ultimately disconnected.
  - Processing plant must be emptied of hydrocarbon liquids and gases, usually by draining, venting and purging with inert gas or water.

Failure to carry out these activities could lead to a release of flammable, explosive or toxic liquids and gases. Entry by personnel into vessels could be dangerous. Fire-fighting capacity could be reduced due to lack of gas-turbine power.

- **Hazards arising during offshore installation dismantlement**
  - Residues could ignite flammable atmospheres, generating significant explosions or flash fires during thermal cutting or grinding.
  - There could be exposure to harmful substances during the breaking up of plant or during entry into vessels.
  - Asbestos could be a hazard.
  - Large objects could be dropped.
  - Fixed systems for fire and gas detection, alarms and firefighting equipment will become progressively unavailable.
  - The means of escape, evacuation and rescue (EER) will similarly become progressively unavailable, with consequent reduction of access to and egress from the installation.
  - Risk to divers during intervention to attach, manipulate, place, survey, strengthen etc.

- **Hazards arising during offshore installation disposal**
  - Contamination of toxic substances during transportation to disposal site.

8.3.2 THE ABANDONMENT SAFETY CASE

Under existing UK regulations, operators are required to submit an abandonment safety case (ASC) to the HSE for approval. This is required to demonstrate that the management systems and audit arrangements are adequate, that major hazards have been identified and risks have been evaluated and measures taken to reduce risk to as low as reasonably practicable (ALARP.)

There are implications for the maintenance regime if there is a significant time lag between decommissioning of the installation and its removal, due to potential deterioration of the installation's integrity. HSE inspection of such structures will be required in the interim.

HSE inspectors should consider preparing a safety case internally or seeking a trial safety case from one or more operators in order to highlight the areas of concern. Such a risk-based approach and evaluation should be useful by assisting with prioritisation of the future topic strategy and ensuring that it is competitive and is appropriately funded.

The safety management system (SMS) will be described in the abandonment safety case that requires approval by HSE at least six months prior to any decommissioning activity. However, it is used only once, and there is consequently not the same ability to audit and review as there is with the operational safety case. There is a need to audit the process and to be alert.

8.3.3 SAFETY MANAGEMENT SYSTEMS

The safety management system (SMS) for the entire decommissioning and dismantlement process will have been described in the abandonment safety case submitted to the HSE for approval at least six months before any decommissioning can take place. The SMS for this phase will only be used once, hence there is not the same ability to audit and review as with the operational safety case. In addition, the operator cannot contract away his liability.

Certain areas of the SMS will require particular attention:

- Structure and Accountability (who does what)
- Hazard Identification (repeated for the various stages of the project)
- Standards and Procedures for Controlling Risks (usual production phase procedures may not be applicable)
- Selection of Personnel (balanced to the needs of the decommissioning and dismantlement project)
- Selection and Control of Contractors (active involvement of the operator)
- Control in Emergencies (for each stage of the project)
- Active Monitoring/ Supervision (elimination of human element considerations e.g. shortcuts).

A review of the specific issues expected to be addressed by the SMS would be a useful guide to inspectors reviewing safety cases and SMS arrangements.

8.3.4 RESPONSIBILITIES

Selection and control of the project team is vital to safety throughout the abandonment programme. As the installation is progressively decommissioned and dismantled control of the process will move from the installation (the OIM?) to the HLV or command vessel. This transfer of responsibility needs to be clearly established in the safety case, SMS and throughout the team.

Decommissioning offshore installations and pipelines will involve significant movements of vessels in the vicinity of the installation, and will involve large numbers of personnel and a variety of specialist contracting organisations. The decommissioning phase of the installation's life is likely to be one of its busiest phases.

Consideration must be given to the fact that there will be numerous vessels involved, arriving at and departing from the installation, lifting, towing, manouvering etc. Safety of the installation and risks to personnel must be managed under these circumstances, with the risk of collisions controlled and minimised.

8.3.5 REVIEW AND AUDIT

Thought needs to be applied to the nature and level of HSE involvement in safety case evaluation and audit, particularly focusing on whether the level of auditing and involvement should be different from the operations safety case, principally because of the one-off nature of the decommissioning process.

8.3.6 EER

The issue of evacuation, escape and rescue (EER) in relation to offshore decommissioning and removal has not received sufficient consideration, principally because most of the platforms removed worldwide have been comparatively small and have been removed relatively quickly and simply [29]. The larger UKCS installations yet to be decommissioned will make the process more difficult, and could result in the EER capability being adversely affected at various stages.

The impact of decommissioning and removal on EER capability should be assessed at an early stage in the planning and engineering phase of platform abandonment, so that potential deficiencies or problems can be identified and acted upon.

The impact of hazards on EER capability should be given particular consideration, with particular emphasis on training a decommissioning workforce unfamiliar with the installation. A change in EER strategy might be appropriate following the removal of hydrocarbons upon production shutdown. It will also be necessary to ensure that the less prominent elements of EER capability (such as escape route signs, alarms and PA coverage) are not impaired or misleading due to ongoing decommissioning and removal work.

Unless the topsides can be decommissioned and removed as a single unit, the duration of the decommissioning and removal programme is likely to extend over a period of several months if not longer for older or larger platforms. Any adverse impact on EER capability associated with decommissioning and removal activities could then be a long term safety issue.

8.3.7 SPECIFIC SAFETY CONCERNS

Several specific safety issues have emerged which warrant clarification, discussion or further research. These are:

- How to deal with biocide which may be present in solution in platform legs. Significance of the concentration if disposed of at sea or for human health of decommissioning workers.
- Permit to work requirements during decommissioning particularly for hot work or work in confined spaces.
- Contingency plans for fractures during lifting or development of adverse weather during critical operations.

8.4 TECHNICAL ISSUES

Previous studies and research have concentrated heavily on technical issues, particularly those associated with explosive cutting and in-situ toppling including its simulation by computer software. With the need to remove all but the 'footings' of the largest structures the emphasis should now change and new issues are emerging. In order to address these in a logical order the principal phases of the abandonment process will be used as follows:

- Planning and engineering
- Cessation of production and pipeline and well abandonment
- Topsides and substructure removal
- Drill cuttings options
- Pipelines recovery or making safe.

In addition a final section will consider the issues raised for abandonment of concrete offshore structures.

8.4.1 PLANNING AND ENGINEERING

The decommissioning process can be regarded as the reverse of the installation process. However much of the labour intensive work associated with offshore installation is carried out onshore in the fabrication yard or in sheltered inshore locations (e.g. installation of lifting attachments, rigging, slings, seafastenings). The reverse process will have to be carried out offshore in more hostile conditions at much higher unit cost and within limited weather windows subject to significant uncertainty. Personnel planning and engineering this process will need to understand the capabilities and uncertainties associated with a wide range of parameters such as:

- Weather forecasting
- ROVs
- Diving
- Cutting (above and below water)
- Lifting
- Welding (e.g. strengthening for temporary conditions, seafastening).

Each oil and gas installation is unique, designed and built for a particular location, water depth and environmental conditions, and subject to the technology available at the time of design, construction and installation. The planning and engineering process will be heavily dependent on the availability of detailed archive information covering:

- Original design assumptions
- Material properties
- Construction details
- Modifications
- Defects discovered during construction and operation
- The current integrity of the structure
- The likelihood of there being undiscovered defects which could prejudice integrity during removal operations.

In many cases this information will have been lost, destroyed or be difficult to locate. There are many unknowns with respect to the removal of the earlier offshore structures that are now approaching the end of their working life. Drawings and calculations are unlikely to be available. Older jackets and modules may not be structurally competent for lift either due to the removal of some structural components or due to modification since installation, and strengthening is likely to be necessary. In addition it may be necessary to strengthen the structure for lifting purposes to ensure the lifting forces can be resisted safely. This will require detailed surveys and development of suitable construction procedures which will rely heavily on existing information on geometry, materials and condition.

Analysis software may require development and validation to deal with dynamic forces during lifting and placement onto a barge in which the HLV, module or structure and the barge have relative motions. Non-linear capabilities will be required to minimise the strengthening requirements.

Jackets with large mudmats in soft soil conditions may be difficult to release due to suction. Research is required to quantify the effectiveness of release aids such as pumping water or jetting under mudmats.

Contingency planning to cover for failure of offshore equipment at critical phases will be necessary. This may include manned intervention by divers.

8.4.2 CESSATION OF PRODUCTION AND WELL ABANDONMENT

There is always the potential risk of a blowout during well abandonment. When well abandonment, production operations and selective decommissioning of redundant systems are all occurring simultaneously, the potential is increased for these activities to interact and create a significant hazard from fire and explosion. The number of personnel on board is also likely to be greater in such a situation than at any other phase in the life of the installation. These risks and hazards must be addressed in the abandonment safety case (ASC).

The presence of toxic materials in conductors, pipelines, risers and topsides equipment needs careful evaluation and detailed procedures for removal.

8.4.3 TOPSIDES AND SUBSTRUCTURE REMOVAL

Several new technical solutions are emerging as alternatives to heavy lift crane barges such as Versatruss and the Offshore Shuttle [16 and 19]. The interface between these systems and the object to be lifted is a critical area and will require careful engineering so as not to promote local failure or overstressing in the region of the lift or support points. Similarly the attachment of additional buoyancy, lifting aids and seafastenings require novel solutions so as not to expose manpower and equipment to risks due to deteriorating weather. Techniques developed for sub-sea repairs which can be installed by divers, ROVs or, above water, by rope access personnel may, with modification, have application for rapid deployment. Stressed mechanical or grouted clamps can provide high capacity over short lengths without the need for in-situ welding.

Cutting methods require further development particularly to deal with thick-walled sections in legs which may be up to 150-200 mm thickness in some locations. Where explosive cutting is used, now that toppling is not an option, the structure being cut will require external support at least for the final cuts and therefore the effect of the explosion shock waves and gas bubble on the support device (e.g. HLV) will need more accurate data and analytical techniques than are generally available at present.

The removal of the larger UKCS steel-jacketed installations poses significant problems. Transporting and seafastening odd structural shapes, and transferring them from a barge onto an onshore quay will raise difficulties and safety issues. There are also unresolved issues associated with the removal of large integrated or hybrid topsides that have yet to be tried and tested.

Heavy lift capability and vessel crane capacity are seriously in question in the light of recent problems e.g. Baldpate and Petronius. The cause of failure that led to the 3600 tonne Petronius module falling from the DB50 into the Gulf of Mexico together with the crane block during a night-time installation has not yet been identified. The module is now resting on the seabed 1750 feet below the water's surface (30). The safety and reliability of heavy lift operations offshore need to be improved, with due account taken of contingencies in the light of possible failure. The associated risks need to be reviewed and understood in detail, and addressed in contingency planning. HSE has a role to play by ensuring that further technology development in this area (e.g. Versatruss and Offshore Shuttle) is encouraged and that due emphasis is placed on the safety issues – see also Section 6.1.

Reinstalling rigging, bumpers, sling laydown platforms, padears and padeyes will require time and engineering effort and add to the decommissioning costs, due to the extensive amount of hot work required offshore. When well abandonment, production operations and selective decommissioning of redundant systems are all occurring simultaneously, the potential is increased for these activities to interact and create a significant hazard from fire and explosion. The number of personnel on board is also likely to be greater in such a situation than at any other phase in the life of the installation. Selection and control of the project team, including contractors, is vital to ensure safety during all stages of the abandonment programme.

All safety hazards and risks associated with offshore hotworking, including escapeways, TR etc. need to be evaluated and addressed.

Innovative forms of mechanical latching sea-fastening devices may need to be developed. At present, units of 2000 to 5000 tonnes cannot be lifted at a near shore location, and will therefore need to be rolled off or skidded off. The lifting and load handling could take place in a number of locations, and issues of safety during load handling will exist and should apply anywhere and anyhow such loads are lifted or raised.

8.4.4 DRILL CUTTINGS OPTIONS

A major joint industry funded R&D programme (14) is currently being undertaken to explore the options for accumulations around North Sea platforms, ranging from leaving the cuttings in-situ to total removal (see Section 6.2.5). This programme encompasses technical and environmental issues. However, the exposure of personnel to associated hazards also needs to be addressed.

8.4.5 CONCRETE STRUCTURES

Whilst a number of studies (including joint industry projects) have been undertaken on aspects associated with the removal of concrete gravity base structures (GBSs), there remain many technical uncertainties. Removal will be particularly difficult for the very large and heavy structures installed in the 1970s and early 1980s. There are twenty-six GBSs in the North Sea located in up to 300 metres water depth weighing from 200000 to 1000000 tonnes.

There are serious doubts over the capability to refloat concrete GBSs with a level of operating risk commensurate with accepted levels for offshore operations. Issues include how to break free of the suction effect, stability after release (potentially large volumes of grout or soil attached to the base) and the integrity of the structure (potential damage during installation).

A current study, being carried out by WS Atkins and jointly funded by the HSE and industry, is examining the engineering safety and environmental risk issues of decommissioning and removing ageing 'first generation' oil production GBSs from the North Sea.

Whether or not concrete structures are eventually removed, it will be necessary to convince all stakeholders on the effects of any oil left inside in order to avoid high risk cleaning operations for little benefit. Only a small amount of residual oil is likely to remain inside a concrete structure after oil removal and cleaning. Further evaluation should be undertaken to reduce uncertainties in the assessment of residual oil and to improve public perception.

9. TOPIC STRATEGY

Decommissioning Topic Strategy objectives are as follows:

“1. To maintain and improve our knowledge on all topics for which we are responsible. (To be achieved through CPD, training, consultation and liaison with all stakeholders).

2. To provide advice, guidance and training to inspectors in supporting their enforcement role to achieve acceptable management and reduction of risk.

3. To represent HSE/OSD interests in our dealings with other stakeholders, e.g. Trades Unions, Industry Associations, OGDs, International Regulators, OIAC, etc.

4. To promote the involvement of the offshore workforce in safety initiatives.

5. To continue to facilitate revisits to existing Competence Training Standards, Industry Guidance, Codes of Practice, etc.

6. To facilitate, where deemed necessary, the development of industry guidance.

7. To review and update topic strategies on an annual basis.”

In order to facilitate development of a more detailed topic strategy for decommissioning the issues identified in Section 8 have been mapped onto the above strategy objectives as shown in Table 9.1. This provides a guide for more detailed appraisal of this document and discussion of the key issues and priorities for a detailed topic strategy. From this it is envisaged that a detailed plan can be developed giving action responsibilities, timescales, budgets for technical support and research projects.

Topic Strategy Objective	Decommissioning Issues
1 Maintain and improve knowledge	8.2.8 Learning from experience including overseas 8.3 Safety Management issues 8.3.1 Hazards and risks 8.3.2 The Abandonment Safety Case 8.3.3 SMS 8.3.4 Responsibilities 8.3.5 Review and audit 8.3.6 EER 8.3.7 Specific safety concerns 8.4 Technical issues 8.4.1 Planning and engineering 8.4.2 Cessation of production/Well plugging 8.4.3 Topsides and substructure removal 8.4.4 Drill cuttings removal 8.4.5 Concrete structures
2 Provide guidance to inspectors	8.2.3 OSPAR implications 8.2.4 Responsibilities between regulators 8.2.6 Regulations 8.3.3 SMS 8.3.4 Responsibilities 8.3.5 Review and audit 8.3.6 EER
3 Represent HSE interests to other stakeholders	8.2.1 Balance between safety, environment, cost 8.2.2 Public perception 8.2.3 OSPAR implications 8.2.4 Responsibilities between regulators 8.2.5 Residual liabilities 8.2.6 Regulations 8.2.7 Reuse, recycling, onshore disposal
4 Workforce involvement	8.2.9 Workforce participation 8.3.4 Responsibilities 8.3.6 EER
5 Revisit Guidance, Codes, Competencies	8.3.1 Hazards and risks 8.3.2 Abandonment Safety Case 8.3.3 SMS 8.3.4 Responsibilities
6 Facilitate development of guidance	8.2.10 UK opportunities 8.3.7 Specific safety concerns 8.4.1 Planning and engineering 8.4.2 Cessation of production/Well plugging 8.4.3 Topsides and sub structure removal 8.4.4 Drill cuttings removal 8.4.5 Concrete structures
7 Topic strategy review	Whole document

Table 9.1 Mapping of decommissioning issues onto Strategy Objectives

10. REFERENCES

1. Prasthofer, P H. 'Decommissioning Technology Challenges'. ODCP/Exxon. OTC 8785, May 1998.

2. Health and Safety Executive. 'Strategy for Offshore Research – 1996/97, Summaries and Objectives', OTI 96 642, 1996.

3. Evolution of the Global Decommissioning Regulatory Regime, W S Griffin, Phillips Petroleum Company. OTC 8784, May 1998.

4. Hill, A. 'Consolidation of Petroleum Law'. Energy Day. 26 November 1998.

5. 'Decommissioning – After OSPAR'. Energy Day. 10 August 1998.

6. Department of Trade and Industry. 'Guidance Notes for Industry: Decommissioning of Offshore Installations and Pipelines under the Petroleum Act 1998'. DTI Offshore Decommissioning Unit, May 2000.

7. Bradbury, J. 'Dumping Ban to Bite'. Euroil. August 1998.

8. 'A Guide to the Offshore Installations (Safety Case) Regulations 1992'. Health and Safety Executive Guidance on Regulations.

9. 'A Guide to the Offshore Installations and Pipeline Works (Management and Administration) Regulations 1995'. Health and Safety Executive Guidance on Regulations.

10. 'A Guide to the Integrity, Workplace Environment and Miscellaneous Aspects of the Offshore Installations and Wells (Design and Construction etc.) Regulations 1996'. Health and Safety Executive Guidance on Regulations.

11. 'Prevention of Fire and Explosion, and Emergency Response on Offshore Installations (1995)'. Approved Code of Practice and Guidance. Health and Safety Executive.

12. Lunt, M G and Sharp, J V. 'Offshore Decommissioning – Development of a Research Strategy'. Presentation to IOCE Conference on 29 to 31 October 1996.

13. 'Assessment Principles for Offshore Safety Cases', HSG181, HSE Books 1998.

14. UKOOA Web Site at http://www.ukooa.co.uk

15. ‘Platforms affected by the OSPAR Agreement’. Energy Day. 12 November 1998.

16. ‘Abandonment Planning Begins for Norway’s Frigg Field’. Offshore, August 2000.

17. Prasthofer, P H. ‘Platform Decommissioning – Finding the Right Balance’. ODCP 17th International Conference on Offshore Mechanics and Arctic Engineering, OMAE98-1432. 1998.

18. Gorman, D G and Neilson, J (Editors). ‘Decommissioning Offshore Structures’. June 1997.

19. ‘Versatruss to Carry Out North Sea Study’. Energy Day, 28 August 2000.

20. Corcoran, M. ‘The Abandonment of Offshore Oil & Gas Fields: Volume One: The Regulatory Framework’. OPL.

21. Street, R and Mirzoeff, J. ‘Research Needs for Health and Safety of Workers during Decommissioning and Removal of Fixed Offshore Installations'. Health and Safety Executive. OTH 95 488. 1995.

22. ‘Minimising the Impact of Decommissioning'. Institute of Petroleum Bound Proceedings. 22 February 1996

23. ‘Decommissioning Projects & Techniques’. Oil & Gas Journal International Two-Day Conference in Aberdeen on 19 & 20 June 1997.

24. Penney, W. ‘Decommissioning Heavy Lift Operations: A Review of Safe Lifting Procedures'. Health and Safety Executive. OTO 98 170, 1998.

25. Fact Sheets & Information Pack. Offshore Decommissioning Communications Project (ODCP), Sponsored by UKOOA, E&P Forum and the Norwegian Oil Industry Association.

26. Bamidele, B. ‘Review of the Hazards and management Control Issues in Abandonment Safety Cases’. Health and Safety Executive. OTH 97 547. 1997.

27. ‘Abandonment of North Sea Platforms’. EuroForum International Two-Day Conference in Aberdeen on 22 & 23 June 1995.

28. Neale, T. ‘Removing, Re-Using or Recycling Redundant Offshore Facilities’. Institute of Petroleum International Conference on Recommissioning. DGXVII – Energy, European Commission. 14-15 October 1998.

29. ‘Evacuation, Escape and Rescue Aspects of Platform Decommissioning and Removal’. Health and Safety Executive. Prepared by W S Atkins. OTH 97 536, 1997.

30. Von Flatern, R. ‘Module plunge puts brakes on Petronius’. Offshore Engineer. January 1999.

31. ‘Brent Spar – A Strange Affair’. Financial Times Energy Economist. July 1995.

32. ‘The Offshore Installations and Wells (Design and Construction, etc.) Regulations 1996. Statutory Instrument 1996 No 913.

33. ‘Ekofisk partners trying to contain high decommissioning costs’. Offshore. October 1998.

34. ‘The Pipeline Safety Regulations 1996. Statutory Instrument 1996 No 825. HMSO, 1996.

APPENDIX A INSTALLATION CATEGORIES

A.1 CONCRETE AND STEEL GRAVITY BASE STRUCTURE (GBS)

There are 12 of these structures in the UK sector of the North Sea, as follows:

Mobil Beryl A Platform
Shell Brent B Platform
Shell Brent C Platform
Shell Brent D Platform
Shell Cormorant A Platform
Shell Dunlin A Platform
Total Frigg MCP-01 Platform
Total Frigg TP1 Platform
Total Frigg CDP1 Platform
Phillips Maureen Platform
Oryx Ninian Central Platform
BHP Ravenspurn North CPP Platform

A.2 VERY HEAVY STEEL JACKETS (VHS)

There are seven such platforms with substructure weight in excess of 20000 tonnes, as follows:

Britannia Platform
Shell Cormorant North Platform
BP Magnus Platform
Oryx Murchison Platform
Elf Piper B Platform
Shell Tern Platform
BP Thistle A Platform

A.3 LARGE STEEL JACKETS (LSJ)

44 such structures are located in water depths greater than 75 metres with jacket weights in excess of 4000 tonnes. 22 of the platforms are deemed to be “difficult to remove”.

Chevron Alba Northern Platform
Total Alwyn North NAA Platform
Total Alwyn North NAB Platform
BP Andrew Platform
BG E&P Armada Platform

Mobil Beryl B Platform
Mobil Beryl Riser Tower
Marathon Brae A Platform
Marathon Brae B Platform
Marathon Brae East Platform
Shell Brent A Platform
BP Bruce D Platform
BP Bruce PUQ Platform
Texaco Captain WPP ‘A’
Elf Claymore A Platform
Talisman Clyde Platform
Total Dunbar Platform
Shell Eider Platform
BP Forties FA Platform
BP Forties FB Platform
BP Forties FC Platform
BP Forties FD Platform
BP Forties FE Platform
BP Forties Unity Riser Platform
Total Frigg QP Platform
Shell Fulmar A Platform
Shell Gannet A Platform
DNO Heather A Platform
Shell Kittiwake A Platform
Amoco Lomond Platform
BP Marnock ETAP PDR Platform
BP Miller Platform
Amoco Montrose A Platform
Enterprise Nelson Platform
Oryx Ninian Northern Platform
Oryx Ninian Southern Platform
Amoco North Everest Platform
Amoco North-West Hutton Platform
Elf Saltire A Platform
Amerada Scott JD Platform
Amerada Scott JU Platform
Shell Shearwater C PUQ Platform
Texaco Tartan A Platform
Agip Tiffany Platform

A.4 SMALL STEEL PLATFORMS (SP)

The study identified 169 structures in this category.

Printed and published by the Health and Safety Executive
C0.5 6/01

HSE BOOKS

MAIL ORDER
HSE priced and free
publications are
available from:
HSE Books
PO Box 1999
Sudbury
Suffolk CO10 2WA
Tel: 01787 881165
Fax: 01787 313995
Website: www.hsebooks.co.uk

RETAIL
HSE priced publications
are available from booksellers

HEALTH AND SAFETY INFORMATION
HSE InfoLine
Tel: 08701 545500
Fax: 02920 859260
e-mail: hseinformationservices@natbrit.com
or write to:
HSE Information Services
Caerphilly Business Park
Caerphilly CF83 3GG

HSE website: www.hse.gov.uk

OTO 2001/032

£15.00

ISBN 0-7176-2054-9

9 780717 620548