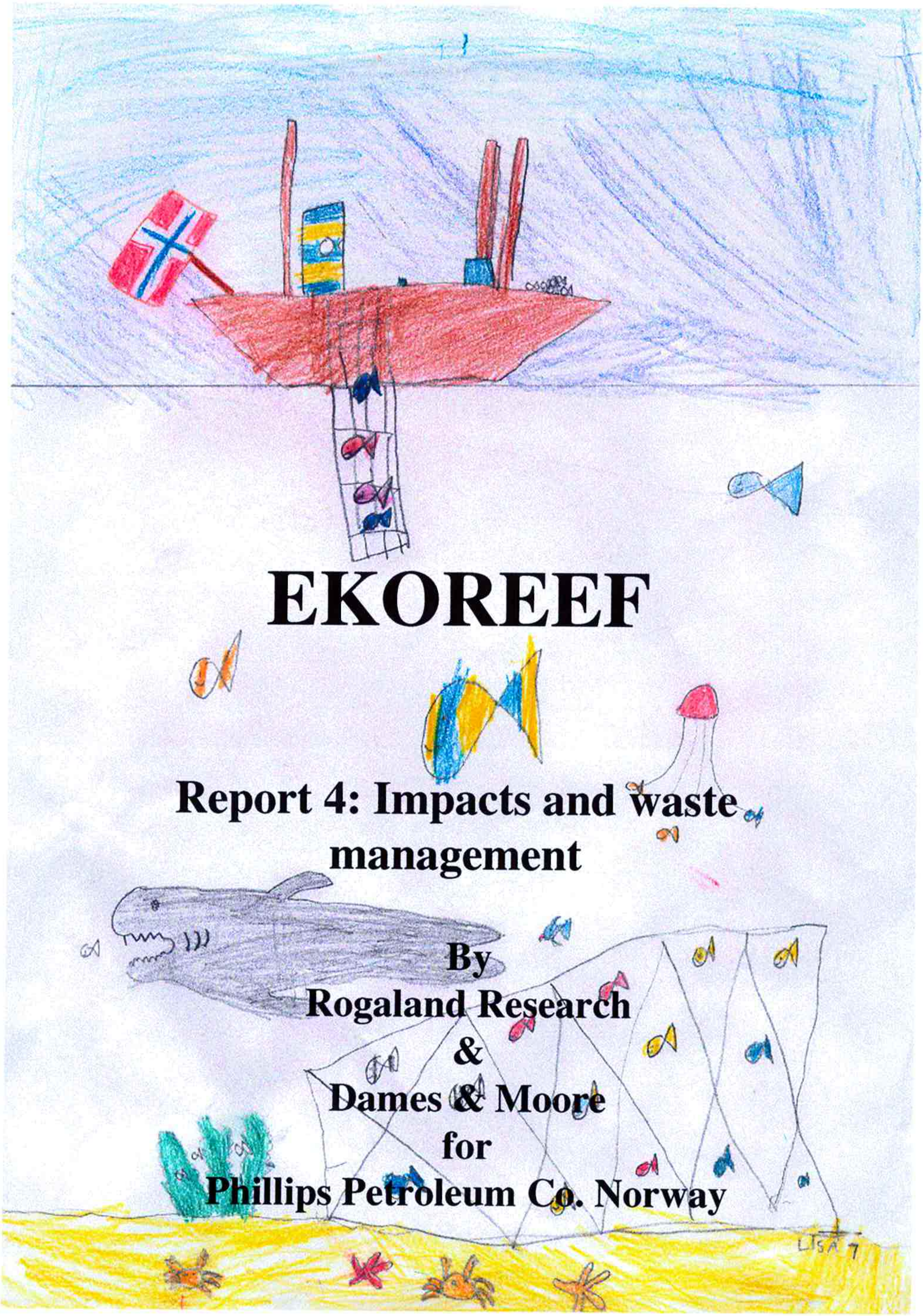

EKOREEF

Report 4: Impacts and waste management

By
Rogaland Research
&
Dames & Moore
for
Phillips Petroleum Co. Norway

EKOREEF - Report 4: Impacts and waste management

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Scope:
This project comprises 3 aspects: 1. To assess the positive and negative environmental impacts of the construction, short-term and long-term reuse of Ekofisk structures as artificial reefs. 2. To predict the socio-economic consequences of such a strategy. 3. A plan for the management of material that cannot be left on the reef will be proposed. The findings of this report are to be summarised and simplified in a main report for the Ekoreef programme.
Key-words: Ekofisk, artificial reef, fisheries, environment, rigs to reefs, GIS, decommissioning, Ekoreef, offshore platforms.

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PREFACE

As the oldest exploited oil field in the North Sea, the Ekofisk field is currently approaching the end of production. Various options are being considered by the operators as part of a choice of field cessation plans required by the Norwegian government. One such option is the use of suitable, prepared, planned and located platform components as artificial fish attracting reefs: the "Ekoreef" option.

This report presents the findings of the third project (report 4) within the Ekoreef programme. A total of 5 main projects have been conducted, and will together assist in the planning and estimation of the potential for one or several complex artificial reefs in the Ekofisk area.

The following reports have been delivered through the Ekoreef Programme:

1. *Summary report* - The main points of the 5 projects have been collated into a concise summarising document.
2. *Present status* - Recommendations have been given as to which areas around both the Ekofisk Tank and the Greater Ekofisk field, appear most suitable for the construction of one or several artificial reefs. An overview of the decommissioned structures available and the general environmental situation, including fishing activities is presented.
3. *Configuration* - Optimal design or designs of a potential Ekoreef have been prepared. These incorporate recommendations for structures to be included in the reef, their configuration, location and the rationale used.
4. *Impacts* - Likely negative and positive impacts on the environment and associated socio-economics have been predicted. A waste management plan is proposed.
5. *Management* - A plan for the management of the Ekoreef, including an assessment of its most beneficial uses, has been prepared.
6. *Monitoring* - A plan for the future monitoring required around the Ekoreef is proposed.

GLOSSARY

Main structures:

1/6A & 2/4F	Albuskjell
2/4B & 2/4K	West Omikron
2/4D	West Ekofisk
2/4E	Tor
2/4H	Ekofisk hotel
2/4T	Ekofisk tank
2/7B, 2/7A & 2/7FTP	Eldfisk
2/7C	Edda
2/7D	Embla
7/11A	Cod

Terminology and acronyms

Benthic	Pertaining to the sea floor.
Biocide	A chemical that is toxic or lethal to living organisms.
Biomass	Quantitative estimate of the total mass of organisms present.
Demersal	Living at or near the bottom of the sea.
Diversity	The number of different species of animals present.
ECR	Effective Consumer Response.
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
Epifauna	Animals that live on the surface of the sea floor
IMO	International Maritime Organisation
LSA	Low specific activity scale
NORM	Naturally Occurring Radioactive Materials
NSTF	North Sea Task Force.
OLF	The Norwegian Oil Industry Association
OSPAR	Oslo and Paris Commission
Pelagic	Pertaining to the water column.
PCB	Polychlorinated biphenyl - a persistent pollutant
SEBA	Sea-based Activity Group of the OSPAR Convention
Sessile	Immovable organisms
UNCLOS	United Nations Convention on the Law of the Seas

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4.1 Summary

The implementation of one or several sizeable artificial reefs using redundant offshore steel structures is likely to have pronounced impacts on the environment, at least in the close vicinity of the reefs. These impacts will partly stem from the construction and long-term presence of the structures as reefs and partly from their removal from use within the petroleum industry. This project aims, at an early stage in the cessation process, to: identify factors that are a special environmental or socio-economic risk or benefit; identify impact reduction or optimisation technology; form part of the project plan presented to the authorities; indicate to interested parties that environmental protection is a major consideration; and present a plan for the identification and handling of waste materials that are not suitable for incorporation into an artificial reef.

Numerous national laws and international conventions govern various aspects of decommissioning and reef creation. OSPAR and Norwegian national legislation, primarily the Pollution Control Act, contain provisions that allow for the creation of artificial reefs providing they do hinder other users and do not cause significant pollution. In order to achieve these requirements, adequate planning is needed and structures must be suitably cleaned of potentially toxic material.

Some limited impacts may realistically need to be accepted, providing that some compensatory benefits or improvements are likely to accrue. 39 environmental and socio-economic impacts, both positive and negative are identified. These are divided into the following sets of impacts relating to: exploitable fish stock (8); local biota (7); sediments (4); water column (2); energy and emissions (2); socio-economic (10); other (6). Not all impacts were necessarily relevant in all, or even any, cases. The likely severity of these impacts in general, and the potential for their reduction (negative impacts), or maximisation (positive impacts) is estimated. Techniques to accomplish this are summarised. Semi-quantitative impact severity scores for each defined possible impact are assigned to each of the 11 reef creation Alternatives described in report 3 *Configuration*. These are totalled for each Alternative, which are then ranked according to various defined criteria.

From an environmental and ecological (including commercial fish stocks) perspective, the use of reefs for protection would seem to be a better option than use for commercial fishing. Differences in impacts between these two options were though not great. Alternative 4, Albuskjell and Eldfisk, was clearly the best option overall. This could have been due to an over-estimate of the different vectors for contaminants in the sediments to be transferred into the environment. It has been assumed that the sea-bed will be left in its current condition. Should cuttings piles be removed, it would be expected that the long-term risk of contamination would be reduced, and hence more centrally located reef sites such as the Tank and the Centre complex, would score less negatively in respect of contamination. With the exception of Alternative 6, the other Alternatives, 1, 2, 3 and 5 scored similarly and hence no reliable difference could be determined. From an environmental and socio-economic perspective, Alternative 6, toppling *in situ* was the worst Alternative. Though outside the remit of this study, it was nevertheless considered the safest option and the cheapest to implement (as indicated by the low energy and emissions score), and hence can not be disregarded. Certain small non-jacket structures, should be incorporated into platform reefs with care, to avoid increasing the risk of debris transport on the sea-floor. The following order of preferences from an environmental and socio-economic perspective is proposed:

1. Protection reefs at Albuskjell and Eldfisk would be optimal.
2. Protection reefs at any of the other complex reef sites.
3. Fishing reefs at Albuskjell and Eldfisk.
4. Fishing reefs at any of the other complex reef sites.
5. Non-specified usage reefs as a result of toppling *in situ* is least optimal, but has other important related advantages.

In order to ensure that materials that are toxic, or in some other way unsuitable for inclusion in an artificial reef, are removed prior to implementation, a general inventory of such materials for a 'reference' installation is presented. The main sources of these materials, their principal components, recommended handling practice and relevant legislation are detailed. A waste management policy based on the Waste Management Hierarchy is proposed, i.e. 1. reduction; 2. reuse/resale; 3. recovery/recycling; 4. disposal at landfill or incineration. The risks associated with the handling of these wastes are assessed. The following is recommended: oil components containing PCBs, halons/freons should be removed; persistent synthetic substances should be removed where possible; production chemicals should be taken onshore for disposal; topside tanks and pipe-work should be cleaned as thoroughly as possible to remove residual sediments (containing heavy metals) and hydrocarbons as far as practicable; and components/equipment containing radionuclides should be removed.

4.2 Introduction

4.2.1 Background

Clearly, the implementation of one or several sizeable artificial reefs using redundant offshore steel constructions is likely to have pronounced impacts on the environment, at least in the close vicinity of the reefs. These impacts will partly stem from the construction and long-term presence of the structures as reefs and partly from their removal from use within the petroleum industry. Indeed, if there were no impacts expected, then the justification for the establishment of reefs would be severely limited. Artificial reefs are designed to have both environmental and, in many cases, socio-economic impacts, though in a positive way. Through careful planning, management and monitoring an aim is to reduce the negative impacts and increase, or optimise, the positive impacts.

It is important, at an early stage in the cessation process to attempt to predict likely impacts and the probability of their occurrence. The Norwegian government requires that 4 alternatives are included in a cessation plan presented for evaluation. The EU also requires the presentation of alternatives. Commonly, an EIA can be used to compare the impacts of these different alternatives. The assessment presented in this report differs from that used to compare different scenarios such as deep-sea dumping, mothballing, artificial reef creation and recovery to land. This report deals specifically with only one of these options and thus seeks primarily to identify potential impacts within this one strategy. An intra-option comparison will though be conducted to compare the different reef creation scenarios presented in report 3 Configuration.

4.2.2 Aims

It is expected that the EIA presented here will be used primarily for internal screening during early abandonment planning.

4.2.2.1 Environment

An Environmental Impact Statement (EIS) will be prepared from the Assessment (EIA). The former can be used to:

- identify factors that are a special environmental risk;
- identify impact reduction technology;
- form part of the project plan presented to the authorities;
- indicate to interested parties that environmental protection is a major consideration.

Specific items to be addressed include:

- the effect that an artificial reef will have on the bottom topography through a change in the current pattern, sedimentation, etc.;
- possible leakage of heavy metals from the anodes;
- leakage of hydrocarbons from piles of drill cutting and possible stabilisation of the piles when creating an artificial reef;
- changes in the local biota, i.e. bottom fauna and fish;
- energy usage and gaseous emissions;
- the potential for long-term impacts from debris and the contribution of non-jacket structures to this;
- comparison of platform reef impacts with, for example, ship wrecks resulting from accidents and deliberate dumping;
- debris.

4.2.2.2 *Socio-economics*

The socio-economic consequences of reef construction and long-term use of the Ekoreef(s) will also be assessed, and will include the consequences for:

- commercial fishermen;
- other users of the region or the reef;
- the reputation of the petroleum industry.

4.2.2.3 *Waste management*

With the assistance of HSE staff at Phillips, a three phase plan (not implementation) for the management of material that cannot be left on an artificial reef will be proposed. It will include:

- baseline determination of conditions offshore including a register of material;
- risk assessment;
- waste management / remediation technology;

Compilation of an inventory of hazardous materials will itself be a project to be conducted prior to decommissioning, and such is not included here.

4.2.3 Format

An attempt to standardise the evaluation of impacts from the decommissioning process has been sponsored by the OLF (Lind and Nesse, 1996). Their proposed format is primarily for inter-option comparisons, but a list of aspects that should be considered is recommended. This is used as a starting point for the current study and will be adapted to suit this study. Their recommended format is as follows:

- Introduction
  - field
  - regulative requirements
- Problem approach
  - to different alternatives
  - aims of the EIA
- Alternative options
  - description
  - materials and quantities
  - possible solutions, basic matrix
  - relevant solutions, alternatives matrix
- Environmental consequences
  - description of influenced area
  - re-use
  - disposal in deep water
  - leaving behind
  - qualitative environmental risk analysis (screening)
  - consequence analysis for whole facility

- summation of consequences for the different solutions

- Social impacts
  - employment repercussions of the alternatives
  - employment repercussions of recirculation
- Avoidance action, follow-up and survey programme.
- Comparisons and conclusions

The recommended introduction to the area has been described in detail in report 2 *Present status.* Regulations will be described in this report. The different alternatives, to reef design rather than disposal options, have been described in detail in report 3 *Configuration.* The aims of this EIA have been presented above. The environmental and social consequences of the different reef creation designs will be discussed in this report. Follow-up and a survey plan have been presented in report 6 *Monitoring.* It can then be seen that all the main relevant points proposed by Lind and Nesse (1996) as a Norwegian decommissioning standard impact assessment, have been covered by the Ekoreef programme.

Further, the Norwegian Environmental Protection Department have decreed that consequence analyses will be presented:

- in a style that is easily understandable to the public, non-specialist. This will include the use of summaries and figures, and avoid the use of technical jargon.
- independently without bias.

The reports of the Ekoreef Programmes as a whole have adopted this format and this report will follow this requirement.

This report will follow the protocol summarised in Figure 4.1.

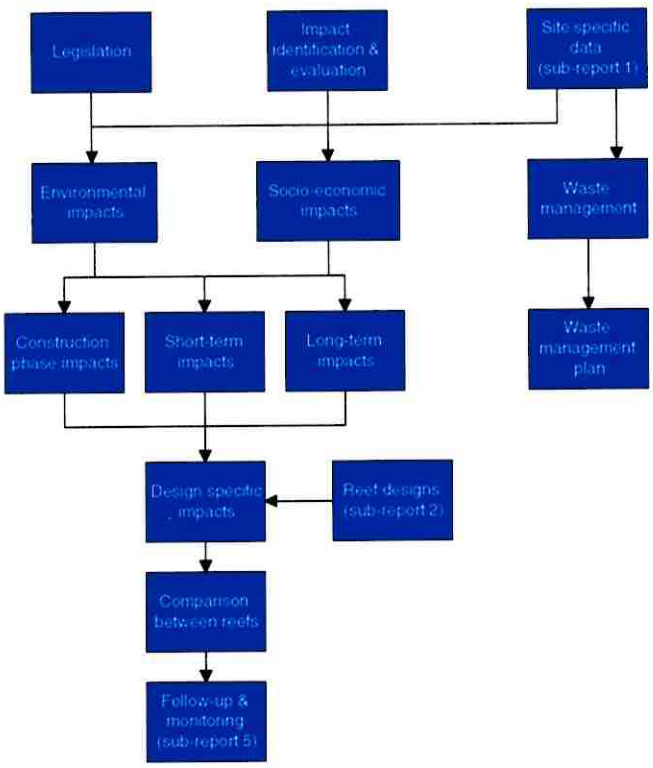

***Figure 4.1**: Stages comprising this Ekoreef impact assessment.*

4.3 Legislation

The legislation surrounding decommissioning in general, and reef creation in particular, is introduced in this part of the Ekoreef programme because the rules were primarily designed to protect other users of the shared resource and the environment.

The relevant international and Norwegian national regulations have been summarised in Cripps *et al.* (1995), OLF (1995) and Lind and Nesse (1996). The following excerpt is an edited updated version of the review in Cripps *et al.* (1995). It should be stressed that prior to decommissioning operations, complicity with regulations should be confirmed by reviewing the original regulative documents. This review is design to give an overview, and should not be considered wholly authoritative.

There are several international and national rules, guidelines and standards that apply to the abandonment of offshore oil and gas related facilities. Currently, the United Nations Convention on the Law of the Seas, and the International Maritime Organisation (IMO) guidelines govern international abandonment. The London and OSPAR conventions, covering the prevention of marine pollution, will also apply to different abandonment options for offshore installations.

The Petroleum Act, with its proposed changes, is the most important Norwegian legislation pertaining to abandonment.

4.3.1 International legislation

4.3.1.1 The Fourth Geneva Convention of 1958

The fourth Geneva Convention on the law of the sea was ratified by Norway in 1971 and governs the continental shelf. The convention sets the international basis of platform abandonment. Article 5.5 of this convention states that:

> *"Any installations which are abandoned or disused must be entirely removed."*

The requirement to remove obsolete installations is designed to safeguard shipping and other rightful users of the sea. When the convention was written, offshore petroleum operations were in their infancy. All fields developed at that time were in shallow waters with small facilities that were easy to remove.

Pipelines are generally not included in the definition of installations (according to the Geneva Convention) and they are not obliged to be removed. This is because pipelines are not considered to represent any impediment to shipping or other users of the sea. This may not however be the case in all situations, especially if pipelines are unburied or unprotected.

4.3.1.2 United Nations Convention on the Law of the Seas (UNCLOS) 1982

This convention entered into force in November 1994 after more than 60 states had ratified the treaty. According to Article 311, this convention now prevails over the 1958 Geneva Convention. Norway and Britain have still not ratified UNCLOS, but this process is proceeding.

Article 60.3 states that:

> *"... 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."*

Article 60.3 of the convention thus implies that not all structures need to be removed completely, in contradiction to the earlier removal requirements of the Geneva Convention. The competent organisation, as mentioned in Article 60.3, is the United Nation's IMO, who have adopted guidelines for the removal of offshore structures on the continental shelf and in the economic zone.

4.3.1.3 The IMO Guidelines and Standards

In October 1985 the secretariat of the former Oslo Commission (see below) invited the Maritime Safety Committee of the IMO to consider the development of criteria concerning partial removal of abandoned and disused installations, from a viewpoint of navigational safety under Article 60.3 of UNCLOS. The Committee decided, in January 1986, to develop guidelines and standards for the removal of offshore installations. In October 1989, these were adopted by the IMO Assembly (IMO, 1989; Appendix 4.1). These guidelines are not formally binding international law, but they are generally accepted as customary law by most coastal states, such as Norway and Britain.

According to the IMO guidelines, abandoned or disused structures standing in less than 75 m of water and weighing less than 4,000 tonnes in air shall be entirely removed. After the 1st January 1998, the depth will be increased to less than 100 m. The 4,000 tonnes limit applies to the jacket without deck and super-structure. Partial removal of larger structures is permitted if there is to be no adverse effect on the marine environment or:

> "*...causing unjustifiable interference with other users of the sea*".

In the cases of partial removal or toppling *in situ*, there must be a free water column of at least 55 m above the remaining parts of the structure. Exceptions from the guidelines may be permitted if removal: is not feasible for practical reasons, as may be the case for larger concrete platforms; if extremely high costs are involved; or there is an unacceptable risk for personnel or the marine environment.

The Official Report NOU 1993:25 states that if an existing installation or structure serves a new function, partial removal may be permitted and exceptions from the IMO guidelines can be made. According to the NOU 1993:25, an artificial reef would not be subject to the 55 m water column requirement under the IMO guidelines, as long as the reef is located:

> "*...well away from customary traffic lanes*".

Article 3.8 of the guidelines states that the location of structures that are not removed from the sea-bed should be marked on nautical charts and, where necessary, be properly identified with navigation aids. The relevant coastal state should identify the party responsible for maintaining the navigation aids.

Article 3.12 states that:

> "*Where living resources can be enhanced by the placement on the sea-bed of material from removed installations or structures (e.g. to create an artificial reef), such material should be located well away from customary traffic lanes, taking into account these guidelines and standards and other relevant standards for the maintenance of maritime safety*".

The relevant clauses in the IMO Guidelines (IMO, 1989; Appendix 4.1) can be summarised and clarified as follows:

3.1 Structures less than 75 m water depth and less than 4,000 t to be removed.

3.2 Increase to 100 m and 4,000 t for new structures after 1 January 1998.

3.3 Removal should not be a risk for navigation or the environment. Positions to be marked.

3.4 Structures in 3.1 or 3.2 can be left behind where:

1. they serve a new use, such as for living resource enhancement;
2. they do no interfere with other users of the sea.

3.5 Structures (even in 3.1 and 3.2) need not be removed if it is not technically feasible, too expensive, or is a risk to safety or the environment.

3.6 Structures in 3.2 and 3.5 (but 3.1 or 3.4 not mentioned) need to have a clear water space of 55 m. By implication, artificial reefs would be excluded from this requirement.

3.7 Redundant structures near shipping lanes must be removed without exception.

3.8 Remaining structures must be marked.

3.9 Remaining structures should not move and cause a hazard to navigation.

3.10 A responsible party for maintaining navigation aids will be identified.

3.11 A responsible party for maintenance and liability will be identified.

3.12 Structures used to enhance living resources should be placed away from shipping lanes.

4.3.1.4 The London Dumping Convention

The London Convention of 1972 (The Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter) is a global convention that regulates, among other aspects, dumping of offshore structures. It states that dumping may only take place after a permit has been obtained from the appropriate coastal state. The directives of the convention will be applicable if a structure is left standing or toppled after termination of use, for the sole purpose of disposing of it. If however, in line with the IMO guidelines, an alternative use can be found for the structures, then the dumping regulations will not be applicable.

4.3.1.5 The OSPAR convention

The Oslo and Paris commissions adopted the new Convention on the Prevention of Marine Pollution in the north-east Atlantic (the OSPAR convention) in September 1992. The Convention has recently been ratified by Norway and Britain. It has been ratified by all signatories with the exception of France. Whilst it has been implemented since 1992 the Convention will come into full force at the next OSPAR meeting in 1998.

The OSPAR Convention is designed to replace the older Oslo Convention (for the prevention of marine pollution arising from dumping from ships and aircraft) and the Paris Convention (for the prevention of marine pollution from land-based sources). The Paris Convention will have no direct relevance to the decommissioning of offshore installations. The new convention has a new offshore annex relating to the decommissioning of offshore installations.

Within the Convention it is required that no offshore installation shall be dumped, or partially abandoned, without a permit issued on a case-by-case basis. No such permit shall be issued if the installation contains substances which result, or are likely to result in:

- a hazard to human health;
- harm to living resources;
- damage to amenities;
- interference with other legitimate users of the sea.

Article 10 states that it shall be the duty of the Commission to draw up criteria, guidelines and procedures for the prevention of pollution from installations dumped at sea or partially abandoned.

Article 1.b of annex II of the Oslo Convention deals with the dumping of, among other things, bulky wastes, which will include offshore installations. Such materials cannot be dumped without a specific permit in each case from the appropriate coastal state. Dumping is only permitted in waters deeper than 2,000 m and more than 150 nautical miles offshore. The Oslo Commission has however stated that these regulations only apply in such cases where the dumping may present a "*serious obstacle*" to fishing or navigation. If a dumping permit is given, it must be approved by all 13 member states.

The Oslo Convention adopted guidelines, in 1990, concerning the disposal of abandoned offshore installations that were similar to those of the IMO. These guidelines give directions regarding the factors to be considered when granting an abandonment permit. Norway has officially expressed reservations regarding these guidelines. It is considered that they restrict the rights of the coastal states.

If the use of a platform is redefined as an artificial reef, it is doubtful that the dumping guidelines and provisions of the former Oslo Convention will be applied. The new OSPAR convention has omitted the depth and distance requirements stated in the Oslo Convention. This would seem to further indicate a general international acceptance of partial removal and the possible use of offshore structures as artificial reefs.

4.3.1.6 OSPAR concerns

Within the OSPAR Convention there is a Sea-based Activity Group (SEBA). In recent years, national delegations to SEBA have expressed concerns relating to aspects of decommissioning and artificial reefs. Whilst these concerns are not legislation, they do indicate the policy that a country is likely to adopt in future negotiations and articles/annexes that may be proposed. The following list of relevant SEBA concerns and the country which expressed them was summarised by Vivian (1998) and Vivian (pers. com.).

Germany 1996 - Artificial reefs:

- loophole for circumventing the objectives of the Conventions;
- changes to natural ecosystems;
- not appropriate for fisheries purposes;
- only acceptable under restricted circumstances;
- ships, tanks (military), vehicles and tyres unacceptable.

Sweden 1996 - Artificial reefs:

- contrary to Articles 2(1)a of the OSPAR Convention;
- loophole for circumventing the objectives of the Conventions;
- construction of artificial reefs for coastal erosion purposes in close vicinity to settlements should not be allowed, in order to protect natural ecosystems.

EU 1996 - Artificial reefs:

- placement of artificial reefs problematic in relation to EU waste and fisheries policies.

Germany 1997 - Artificial reefs:

- reiterated previous concerns;
- opposed to the use of most waste materials in artificial reef construction, particularly ships and offshore structures.

  Considered certain uses unacceptable:
- developing habitats for crustacean fisheries;
- providing substrates for algae or mollusc cultivation;
- providing a means of restricting fisheries.

Sweden 1997 - Objected to the use of artificial reefs for:

- replacing habitats;
- mitigating habitat loss.

EU delegation 1997 - Artificial reefs:

- Biomass improvements would affect fisheries management, i.e. the Common Fisheries Policy.

It would then appear from these concerns that Germany and Sweden are outspoken against artificial reefs in general and the uses to which they may be put in particular. Other countries such as Britain, Norway and Spain have a more pragmatic approach to artificial reefs constructed using waste/recycled material, probably borne of necessity within their own countries. Whilst no firm guidelines have yet been agreed, Spain and Germany will be jointly drafting the guidelines for the SEBA meeting in February 1998. It remains to be seen if Germany's negative viewpoint will be possible to be tempered by the views of other delegations.

4.3.2 Norwegian legislation

4.3.2.1 The Petroleum Act

The Petroleum Act of the 22nd March 1985 contains regulations for the governmental acquisition and disposal of offshore installations and structures. In 1990 the Norwegian Petroleum Committee was requested to draft regulations concerning decommissioning and disposal of offshore installations and structures, since it was recognised that the legal framework for the petroleum industry was insufficient. This resulted in recommendations that were discussed by the Norwegian parliament in the autumn session of 1995 (see Act 72 below). The recommendations are presented in the NOU 1993:25, and by (Fjellså, 1995).

Section 30 of the Petroleum Act describes four alternative disposal options for offshore installations when the licence expires or when the use of the facility terminates:

- governmental acquisition;
- removal;
- leave in place, and initiate safety precautions to avoid damage or inconvenience;
- agreement on temporary use.

No preference between the different options is stated. Removal or alternative use of an installation is regulated by section 30, paragraph 5, which states that the Ministry of Oil and Energy may demand that the licensee removes the installation to prevent damage or inconvenience to other users of the sea. Such a decision must be made within two years after production has ceased, or the license has lapsed. No provision is made as to which party has the future responsibility for an abandoned installation.

The changes to the Petroleum Act, proposed by the Petroleum Committee, are broadly in line with the original text, but some new sections are presented. These constitute a new chapter in the Petroleum Act, which annuls the former Section 30. The new sections include:

- The licensee is obliged to submit a cessation plan to the Ministry. The plan shall include sufficient information for the Ministry to make a decision on future dispositions.
- No preference for any disposal option is given, except for pipelines which can be left *in situ*, unless they constitute a hazard for other activities or represent a pollution risk.
- The decision on disposal will be made on a case-by-case basis following the assessment of the cessation plan by the authorities. Developments in international law will be taken into consideration. Following this practice, any alternative use is a viable option, as long as it does not hinder other rightful users of the sea.
- The government shall acquire ownership of, and resume responsibility for, the facility if it does not approve the cessation plan, does not agree on future disposal of the facility, or does not demand removal. Governmental acquisition will be followed by a financial settlement.

Establishing an artificial reef may be viewed as both an alternative use and a final disposal of a facility. The proposed changes to the Petroleum Act allow the government to resume responsibility for the installation in either case.

Act No. 72 of 29 November 1996

This is the main legal framework for the offshore oil and gas activities on the Norwegian continental shelf and contains provisions to regulate the responsibility of the owner of an installation in connection with its removal.

Chapter 5 of the Act is the core provision relating to disposal and covers the main obligations of operators.

In its Section 5.1, the Act requires the licensee to submit, for approval by the Ministry, a decommissioning plan. This should contain the operator's proposal for the future disposal of their redundant facility along with information and appraisals relating to technical, financial, safety, environmental matters, as well as consideration to other users of the sea. The time for submitting such a plan shall not be earlier than five years and no later than two years before the anticipated time at which use of a facility will finally be terminated.

The subsequent decision-making process for the disposal will be based on this plan. To provide the Ministry with a basis for making decisions concerning future disposal, the following options shall be considered in the Decommissioning Plan:

- continued use in petroleum activities;
- other use;
- abandonment in place;
- partial / total removal.

4.3.2.2 The Removal Cost Division Act

The Removal Cost Division Act (Act No. 11 of the 25th April 1986), concerning the division of costs for removing continental shelf installations, will be applicable if paragraph 5, section 30 of the Petroleum Act is invoked, i.e. the operator is required to remove an installation. The government's share of the total removal cost will be calculated according to an equation contained in Section 2 of the Removal Cost Division Act, based on the average tax rate of the licensee during the production phase of the structure. According to a proposal of the Petroleum Committee, the licensee should pay the government:

- the current market cost for marking the position and maintenance of the facility;
- costs for any future liability for damage and inconvenience to other users of the sea;
- removal costs.

On the other hand, the government must repay any economic benefits to the licensee arising from taking over the installation. This proposal would simplify the system currently resulting from the Removal Cost Division Act. The Act as it stands, and the changes proposed, relating as they do to removal, do not have any direct consequences for artificial reef creation, other than economic comparisons between the reefs and total removal options.

4.3.2.3 The Pollution Control Act

The Pollution Control Act (section 4 of Act No. 6 of the 13th March 1981) regulates continental shelf activities. Fixed offshore installations are not covered by the Act, but toppling of a fixed installation will be subject to Section 4 of the Act. It is, for example, accepted that, when the legs of a jacket are cut, it will no longer be regarded as a fixed installation. The preparations leading to dumping any type of facility on the continental shelf will be covered by the Act, but the actual dumping is covered by the

Seaworthiness Act (and the London and OSPAR conventions). For the case of creating an artificial reef, the Act will only come into force if toppling is planned, not moving and dumping. It is not known if the deliberate placement of topside modules near the toppled jacket would be considered as dumping, especially if another use, i.e. artificial reef, is defined.

If, according to section 7 of the Pollution Control Act, disposal is considered to be covered under the Act, then a permit from the Ministry of Environment is necessary prior to disposal. Within the permitting process, the pollution disadvantages will be weighted against the other advantages and disadvantages of the means of disposal.

Section 13 of the Act concerns the reports and consequence analyses that are obligatory. This conforms to the proposal given in NOU 1993:25. Section 14 requires a public meeting to be held.

Securing the best possible environmental protection when disposing of installations after termination of use, may dictate amendments to the Pollution Control Act. The Ministry of Environment has stated that this will be considered in connection with the pending review of the Act. It is not yet known what consequences this may have for artificial reefs.

4.3.3 Differences between national and international legislation regarding the creation of artificial reefs

In respect of international law, Norway is party to a number of international conventions, more specifically to the *1982 United Nation Law of the Sea Convention* and as such, Norway is under obligation to take into account the International Maritime Organisation (IMO) *Removal Guidelines and Standards. The IMO Guidelines* (Appendix 4.1) were revised in January 1989 with the primary aim of ensuring safety of navigation and avoiding interference with other users of the sea. The IMO Guidelines and Standards, Article 3.12 states that:

> *"Where living resources can be enhanced by the placement on the sea-bed of material from removed installations or structures (e.g. to create an artificial reef), such material should be located well away from customary traffic lanes, taking account these guidelines and standards and other relevant standards for maintenance of maritime safety."*

In relation to regional legislation, Norway is also a signatory of the much debated *OSPAR Convention*. The provisions of Article 5 in this convention further emphasis that:

> *"A permit for disposal shall not be issued if there are substances present, which are likely to result in hazards to: human health; living resources; marine ecosystems; amenities; or result in interference with other users of the sea."*

It is clear that in order to gain consent to dispose of a structure *in situ,* or at another location, the materials listed in Annex III of the convention will need to be removed as far as it is reasonably practicable. In essence, the decision to remove or allow to remain will be a balance between the following factors:

- the environmental effects if the materials are allowed to remain;
- the health and safety risk associated with the removal;
- the cost of removal;
- meeting the intentions of the international legislations relating to dumping.

A far as national law is concerned, the core provision is contained in the *Act of 29 November 1996, No. 72*, regarding Petroleum Activities. This Act, which replaces the *1985 Petroleum Act* came into force on the 1 July 1997. Regulations and guidelines pertaining to the Act are however being drafted and have not yet been finalised.

The decommissioning of any offshore installation will have to be carried out in accordance with domestic, regional and international laws and recommendations. Norway has a comprehensive local legislative framework relating to the decommissioning of offshore structures once their useful life comes to an end. Increased attention is being paid to re-using installations at new locations, either for use in the petroleum industry, or for other purposes such as an artificial reef. The IMO Guidelines have a dispensation for alternative or new use of disused offshore installations. The Petroleum Law Committee's Report on the *Close Down of Petroleum Production and Future Disposition of Installations,* states that the IMO Guidelines are open for alternative use/new use of disused offshore installations, such as artificial reefs. They state:

> *"Since the facility serves another purpose and is not abandoned in the usual sense of the word, an artificial reef* will not be subject to the 55 m water column requirement *under the IMO Guidelines."*

The depth of the sea at the Greater Ekofisk Field is on average 80 m. Ekofisk 2/4-K has dimensions of 67 x 77 m at its base, whilst many of the large platforms have base dimensions of 50 x 65 m. The platforms will, when placed horizontally (i.e. with the shortest base length extending upwards), have a water clearance of about 10 - 15 m for the Ekofisk 2/4-K and at least approximately 30 m for the other structures. Although, the IMO Guidelines state that the 55 m water column requirement does not apply for an artificial reef, the structures lying on the seabed must be properly marked and these navigation markers must be well maintained.

Simplified, *The Petroleum Act*, section 30, states that the decision on disposal will be made on a case-by-case basis following the assessment of the cessation plan by the authorities. Developments in international law will be taken into consideration. Following this practice, any alternative use is a viable option, as long as it does not hinder other rightful users of the sea.

4.3.4 Conclusions

- It would therefore appear that both international agreements (primarily OSPAR) and Norwegian national legislation (primarily the Pollution Control Act) contain provisions that allow for the creation of artificial reefs providing they do hinder other users and do not cause significant pollution.
- In order to achieve these requirements, adequate planning is needed and structures must be suitably cleaned of potentially toxic material.
- The legal framework relating to the decommissioning of offshore installations is well established in Norway. The core provision concerning removal is contained in *Act of 29 November 1996, No. 72*. Waste management and health and safety issues are regulated by a comprehensive set of regulations.
- With regard to international law, Norway has signed and ratified the main conventions; i.e. the *1958 UN Geneva Convention on the Continental Shelf*, the *1982 UN Conference on the Law of the Sea* and the *1972 London Dumping Convention.*
- While the general requirement of the *1989 IMO Guidelines* is for total removal, these regulations do provide for the fact that under certain circumstances the total removal of an installation would be either not technically feasible, involve extreme cost, or would present an unacceptable risk to personnel or the marine environment. These guidelines do not preclude a coastal state from adopting more stringent requirements especially concerning other operations involved in the disposal program, such as well plugging and abandonment.
- The IMO Guidelines contain provisions that allow artificial reefs to be established from installations, without the requirement of a 55 m free water column, provided that they are located well away from shipping lanes and are marked.

4.4 Potential environmental impacts

4.4.1 Defining acceptable options

Several grades of environmental impacts can be imagined. These are listed in Table 4.1 in order of increasing negative severity.

***Table 4.1**: Scale of impacts.*

	Negative impacts		Positive benefits
0	No effect likely.	0	No effect likely.
-1	Limited distribution / low intensity / short-term.	+1	Benefits limited in terms of extent or time.
-2	Marked or significant intensity or distribution for longer than short-term.	+2	Likely in the long-term after reef has become established.
-3	Serious long-term damage to significant region or part of the ecosystem.	+3	Significant almost from implementation.

Each of these four categories can be described in greater detail, but for the purposes of a general estimation of acceptability of a range of impacts, they may be considered adequate.

Clearly category 3 will not be acceptable. Should significant longer-term damage to a part of the marine environment be likely, without the likelihood of accrued benefits in the way of compensation, then the reef creation scenario will not be accepted. Alternative reef creation or decommissioning options will need to be found as an alternative.

The reverse situation in category 0 is also highly unlikely to occur as a result of reef creation. Whilst positive benefits would hopefully quickly accrue, some negative impacts of industrial activity or changes in the natural ambient environment can be expected. To return the sea-bed to virgin sediment in the condition it was in prior to the presence of the oil industry, would require the removal of all platforms and associated structures, as well as the renovation, removal and or replacement of any altered or contaminated sediments. This is likely to be an unrealistic aim, both in terms of the technical feasibility and the cost-benefit.

The limit of acceptance will probably lie between categories 1 and 2. Hence, some limited impacts may realistically need to be accepted, providing that some compensatory benefits or improvements are likely to accrue. In a study of the impacts of dealing with oily drill cutting piles on the sea-floor during decommissioning, Kjeilen *et al.* (1996) suggested that an acceptable criteria may be to return the sea-floor to a condition that allowed other industries to use the location. Whilst this initially appears to only consider the implications in terms of industrial usage, it also considers the condition of the natural environment, as it is this that industries such as fishing exploitation.

4.4.2 Types of impacts

Three types of environmental impacts relevant to this study can be defined:

1. Operational - short-term or local impacts resulting from reef construction and field cessation operations.
2. Short-term end-points - impacts that occur during the establishment of the reef and its integration into the ambient environment (for first 2 - 3 years).
3. Long term end-points - impacts on the ambient natural environment that occur for longer than would be expected for the reef to become established (i.e. after ca. 2 - 3 years).

In the list of potential impacts in the following section, an indication will be made as to which severity category and type is applicable.

4.4.3 Identification of potential environmental impacts

4.4.3.1 Impacts on the exploitable stock

In the case of reefs on the Ekofisk field, the exploitable stock refers to commercially caught pelagic (water column swimming), demersal (near the sea-floor) and benthic (on the sea-floor) fish. Other species that are caught in the North Sea (e.g. lobster, *Hommarus gammarus* or scampi, *Nephrops norvegicus*) may not be relevant in this case because of unsuitable environmental conditions, e.g. too great a depth or inappropriate reef habitat respectively. The first 2 impacts below have been described in more detail by Polovina (1989).

1. *Redistribution of exploitable biomass.* The fish move to or away from the reef, but the stock in the area is not increased. Aggregation of juvenile or adult fish is often a main aim of those wishing to create reefs. Instead of fishing over a wide area, activity will be centred around a reef. It is a well-known fact that offshore structures do attract and concentrate fish (Cripps *et al.*, 1995). A major uncertainty with the establishment of artificial reefs is on the other hand the degree to which reefs concentrate fish and what the effect will be on the fish stocks in the region as a whole (Aabel *et al.*, 1997).

2. *Increased exploitable biomass, but not total stock.* If attracted to a reef, fish that otherwise were not usually caught may become more accessible to capture. This could occur if the fish were previously too dispersed to justify commercial targeting or the reef allows smaller fish to be caught. The total stock does not increase, but more fish are able to be caught.

3. *Increased stock due to production of new individuals.* As a result of the reef providing a greater number of niches for protection from predators or increased quantities of food species, more fish may survive to produce juveniles (the reef does not necessarily need to be located on the spawning ground itself). In this case there would be production on the reef. Despite many studies, little evidence of increased production has been found.

4. *Increased stock due to reduced mortality.* A more likely scenario is that the reef, again through the provision of food or shelter, allows more juveniles to survive to a size where they recruit into the fishery (i.e. become big enough to be caught). Whilst new fish are not being produced, juvenile fish that would otherwise have not survived may survive to be fished. Vast numbers of eggs and juveniles are produced so that a very few can survive. By increasing survival slightly at the juvenile stage, there is a potential to greatly increase the number of small fish surviving. There is a heated debate within artificial reef research at present as to whether this can be termed production.

5. *Growth overfishing.* If impact 2 occurs and too many small fish are taken, then lower catches may result in the longer term than could have been achieved had the fish been allowed to grow larger before being caught. This is considered unlikely in the heavily fished North Sea where there are strong regulations on gear, in the form of minimum net mesh sizes, to restrict the capture of undersized fish. Changes in gear on the reef, for example from trawls to long lines, that may also effect the size of fish caught will be discussed in report 5 Management.

6. *Recruitment overfishing.* If impact 1 or 2 occurs and the fish are made easier to catch as a result of their accessibility or denser distribution, adult fish that would be expected to form the spawning stock may be reduced in number, thus reducing the number of juveniles growing to a size of which they could be caught. In theory recruitment over-fishing could occur if a food species of a commercial fish was caught, so reducing the survival of the commercial species. Again in the North Sea this is considered unlikely. Within sensible limits, the production of new individuals is not limited by spawning biomass because of the large numbers of eggs a single commercial fish can produce. Also, strict quota limitations are in place in the North Sea, preventing the increase in fish that may be taken, even if new methods or equipment (such as an artificial reef) become available. Localised stocks with a slow immigration rate may though be effected. Such stocks have though been shown to be important in the Ekofisk area (report 2 Current status).

7. *Changes in predator mortality.* Contrary to impact 4 above, a reef could in theory increase not only the mortality of fish due to fishing effort, but also mortality resulting from predatory fish. If the reef does indeed serve to attract fish, then the larger fish attracted may eat the juveniles there. This may even be a reason for the reef's attractiveness for larger fish. Whilst such a theoretical scenario has often been proposed, it is also considered unlikely to occur, because juveniles are unlikely to be attracted to or stay in an area in which there is a higher density of predators than the surrounding off-reef region. There is though no evidence to support this hypothesis.

8. *Tainting or contamination of stocks.* There is a risk of the uptake of contaminants from sediments, through the food chain to be accumulated in fish. The sediments around several installations have been found to have a appreciable THC and heavy metal contaminant levels. Even though these contaminants have levelled off in the last years and are restricted to limited areas, there are still some areas left with high THC and heavy metals concentrations in the sediment. Oil installations also contain varying quantities of other materials that will pose a significant risk on the local biota if leached into the environment. Aabel *et al.* (1997) reviewed the tainting and contamination of fish as a result of offshore activity in the North Sea. Their conclusion was that whilst there was some contamination of fish in general, this could not be correlated with their distance from offshore facilities, except bottom living flatfish, as found by McGill *et al.* (1987). Petroleum-based hydrocarbon contamination has though been traced to aged material in oily cuttings piles, of which there are several on Ekofisk. The presence of hydrocarbon tainting in fish was too low to be detected by the average consumer (McGill *et al.*, 1987). The placing of a reef in a contaminated area, particularly on an oily cuttings pile, could lead to an increased uptake of contaminants by the reef fish, though there is currently no evidence to support this supposition.

4.4.3.2 Impacts on the local biota

9. *Changes in epifauna species* (substrate surface living animals). Construction of an artificial reef in the North Sea will give an entire habitat that would not naturally occur there. Hard elevated substrata would be placed in an area where there was formerly none, other than that as a result of the presence of the operating platforms. This habitat will result in the presence of animals not naturally present in the region, in which soft sediments predominate. Animals living upon, or associated with, hard bottoms are collectively called epifauna, and the specific species composition will depend on the configuration and the complexity of the reef. The reef also

provides a range of habitats throughout the water column allowing different species to remain at their most favoured depth. This increased diversity could be considered either a positive or negative impact. Some would consider that the increase in species diversity (the number of different species of animals present) would be beneficial. There is though an opposing view that changing the diversity from that which 'naturally' occurs, even if few species were present, is a negative impact, and as such should be avoided.

10. *Increases in the epifauna biomass.* Compared to the already existing muddy/sandy habitat an artificial reef will provide a large hard surface area, which encourages abundant biofouling and benthic hard bottom species. The configuration and complexity of the artificial reef are of special importance for the fauna in the area. Artificial reefs can be built to provide a greater surface area, elevation, protection for currents or niches/crevices to favour target species (Aabel *et al.*, 1997).

11. *Changes in the sea-bed animal populations.* An artificial reef can affect the local sediment fauna by altering the surrounding physical environment, such as the water motion, sediment-size distribution and organic content of the sediment (Ambrose & Anderson 1990; Davis *et al.*, 1982).

12. *Smothering of endemic fauna.* The operation of implementing the reef, by lying the platform in place will cause some sessile (immovable) animals to be covered by the structure. The surface area that would be covered would be small as the platform jackets are open structures comprising caissons rather than walls. It is also expected that a certain amount of resuspension of bottom sediment would occur during the implementation phase. In the close vicinity of the reef this would be expected to have a smothering effect on animals that are filter feeders. Deposit feeders would also be covered, but could burrow out of the extra sediment.

13. *Changes in platform bio-fouling communities.* Currently operating platforms in the Ekofisk area are heavily covered in fouling organisms. If the platforms are not used to create reefs then these organisms will be lost to the region. If the platforms are toppled or placed on their side, then those animals that occur in shallow, photic depths or even in the surf zone may not survive at the greater depths. They will be out-competed or replaced by deeper water species.

14. *Contamination of local animal communities.* If the structure is not adequately cleaned and prepared prior to decommissioning, then it is possible that hydrocarbons and heavy metals may leak or leach into the environment and from there be taken up and bio-accumulated in the food chain. Whilst possible, this eventuality is considered unlikely, because it is requirement of reef creation that all structures used should be free of contamination. If this is not so then this decommissioning scenario must be considered a dumping rather than reef creation option, and as such will be governed by regulations detailed in section 4.3.

15. *Changes in infauna communities.* If the reef does indeed attract higher densities of commercial fish than the surrounding region, then the levels of predation on the endemic animals in the sediment may well increase markedly as a result of fish foraging in the adjacent sediments. This could result in a local reduction in the number of benthic organisms and a change in the species diversity.

4.4.3.3 Impacts on the sediment

16. *Resorting of surface sediments.* As with impact 11 above, the operation of laying the reef in place is likely to result in substantial resuspension of sediments most of which will probably settle locally. Lower, possible anoxic sediments may then be brought to the surface. These may or may not also be contaminated with historic oil-field discharges from times when discharges were not as controlled as they are today. Changes in the grain-size distribution and organic content of the sediments my result (Ambrose & Anderson, 1990).

17. *Scouring / deposition.* The presence of a sizeable structure as a reef would be expected to change local flow patterns. This could lead to some areas being scoured and some areas in which the moved sediment is deposited. Some uncovering of historic contaminants and smothering or digging out of sediment fauna could occur, but this is expected to be restricted to the close vicinity of the structure. It is possible that extensive scouring could effect the stability of the platform.

18. *Contamination of sediments.* It is possible that the operation of laying the reef in position and the continued presence of the redundant platform could result in the contamination of the surrounding sediments. As stated in impact 16 above, any material resuspended during the toppling or positioning operation could contain contaminants that would otherwise have been locked into the sediments. It would be expected that the risk of contamination would be serious if the reef were located on an old oily cuttings pile. Disruption of such a pile could cause considerable local contamination as described by Cripps *et al.*, (1998). As stated in impact 14, leakage or leaching of material from the structure could cause contamination in the ambient environment, though again, this is considered unlikely as the structure should be cleaned prior to reuse.

19. *Debris.* Both the operation of implementing the reefs and their ageing may result in the production of debris. Water currents in the region may carry this debris away from the reef zone where it could present a safety risk or at least a hindrance to fishing and other offshore activities. Structures must be positioned with care to avoid their damage and the breaking off of pieces. The use of small non-jacket structures should also be avoided, unless they are stabilised by anchoring or by positioning under the main structure.

4.4.3.4 Impacts on the water column

20. *Flow changes.* It is expected that the presence of a large platform structure as a reef will alter water flows, causing local eddies. This may be considered a positive impact as it is these eddies that may be at least partially responsible for attracting fish. The eddies may cause plankton to become entrained, though this is far from certain.

21. *Water column contamination.* The operation of placing the reef or its continued presence may lead to some contamination of the water column and/or the plankton therein. As the majority of heavy metals are associated with the sediments, it is expected that any resuspended material will fall out of suspension. Lighter hydrocarbons may remain in the water column, especially on the surface. Contamination, as stated above could be reduced by locating the reef away from contaminated sediments especially oily cuttings piles. Again as stated above, contamination from the structure itself should be minimal, because it should be adequately cleaned and prepared prior to reuse.

4.4.3.5 Energy and gaseous emissions

22. *Energy usage.* Various operations involved with the creation of reef units will use energy. These include, cutting, lifting with cranes and heavy lift vessels, and transport by barge and tugs to the reef complex site. The energy used is derived from the quantity of fuel consumed in the operations.

23. *Gaseous emissions.* Similarly to that described under the previous point, the reef creation operations will produce various emissions to the atmosphere. These will include carbon dioxide (CO_2), nitrous oxides (NO_x), sulphur oxides (SO_x) and aromatic hydrocarbons (HC).

A summary of the potential environmental impacts of the re-use of Ekofisk structures as artificial reefs is shown in Figure 4.2.

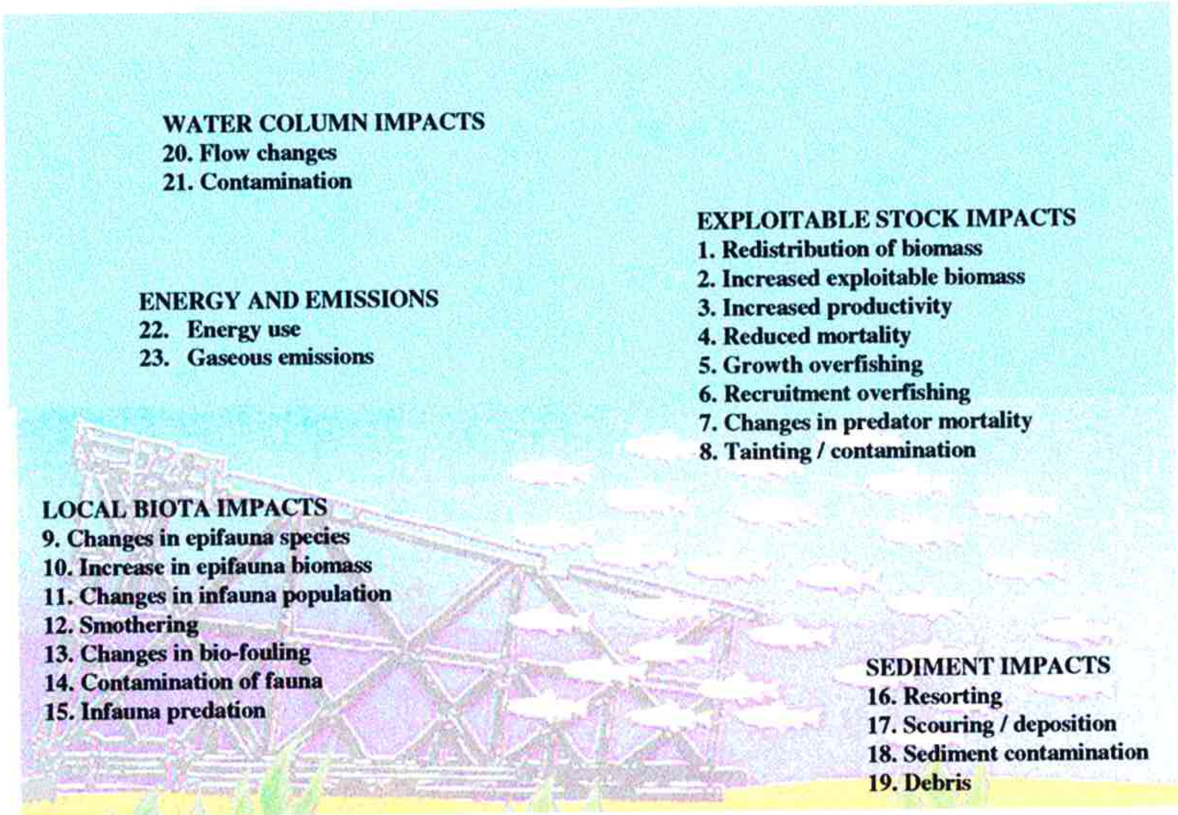

***Figure 4.2**: Summary of potential environmental impacts*

4.5 Socio-economic impacts

4.5.1 Potential socio-economic impacts from artificial reefs

Intuitively, it can be imagined that the establishment of artificial reefs in the middle of the North Sea would have only marginal impacts on the life of the average person onshore. A section of the public do though have strong opinions regarding the issue of how oil companies should and should not discard their redundant platforms, especially in light of the *Brent Spar* case. Nevertheless, the effects of public opinion on company reputation should not be neglected.

Unless the public have strong feelings about man-made structures remaining on the seabed, artificial reefs could be perceived as an integral, environmentally benign, part of decommissioning. This should however be regarded as a benefit (cost) associated with the decommissioning process rather than as a result of a reef building policy as such.

In the literature, the socio-economic impacts of artificial reefs are almost always evaluated with respect to their function as a habitat for fish. This is primarily of interest to fishermen or sports divers. The latter group is however, irrelevant as Ekofisk is a long distance offshore. Thus, ignoring any effects arising from the risk of contamination, as discussed elsewhere in this report, this section will present an assessment of artificial reefs from the perspective of the commercial fishing industry.

4.5.2 Fisheries economics

A formal introduction to fisheries economics is given by Neher (1990), who presented a number of models that could prove useful in an evaluation of fishing in a proposed reef area. Given the lack of available data however, there is little point in applying advanced models at this stage. Simulations could though be run once reliable stock estimates have been obtained. A simplified general production function for a fishery (Neher, 1990) may though serve as a useful starting point in the analysis:

$x = F(a,b)$

where:

x = catch; F = fisheries production function, comprising: a = effort, b = stock

Simplified, the fisherman's objective is to acquire as large a catch x as possible, subject to search effort a and the fish stock b. The fisherman, like any other producer, is deemed to be a profit maximiser, and therefore wants costs per fish sold to be as low as possible. An artificial reef can improve the fisherman's lot if one of the following assumptions are satisfied:

- the reef habitat sustains a larger fish stock b, the growth of which will be higher and thus increase the sustainable annual harvest potential
- a significant proportion of the fish are present within the limits of the reef area, so less time need be spent acquiring a specific catch x.

The benefits can be measured in two ways, depending on the behaviour of the fisherman following the establishment of an artificial reef habitat. Neither benefit arises from an increase in fish biomass:

- if a higher catch x for the same search effort a (i.e. time spent at sea) as before is chosen, the benefit can be measured in the change in income generated. This will be subject to an identical composition of individual fish types, their market prices etc.
- the other option is to catch the same amount of fish x as before, but for a lesser search effort. The fisherman will now have more free time or time to work at other things. The welfare gain can be measured for example by the average hourly wage rate.

Moving one level up from the individual fisherman, an increased catchable stock could theoretically, instead of "enriching" fishermen already in the business, also permit new entrants. This would increase employment in the fishing industry. The cost threshold for entrants, provided that they are not already in possession of the necessary equipment, is however high, so the expected yield would have to be substantial to attract them.

If the biological conditions are such that an artificial reef could be described as a "wild" fish farm or sea-ranch, it would imply potential positive effects for the logistic side of fish processing. Given a more secure minimum catch, or supply of a particular type of fish at any given time, storage and transport costs could be better planned. Hence, an aim would be to satisfy export markets on an Effective Consumer Response (ECR) basis, with prompt delivery "fresh from the sea.".

4.5.3 Who should be allowed to fish on an artificial reef?

Fish are a treasured, shared resource, as demonstrated by conflicts between fishing nations such as Norway, Iceland, Spain and Canada. The question of who should be allowed to fish in a reef area is not a simple one. Fishing in international waters is governed by international maritime law, and in the case of the north-east Atlantic, by the Common Fisheries Policy and other multi or bilateral treaties. The higher the expected gain in terms of fish stock, the more sensitive the issue as to who should fish there will be. Fishing rights could be assigned to certain groups, such as co-operatives, assuming that the stock of fish outside the reef area will be no less due to the growth within it. It is generally easier to divide a new or growing resource. Legal and political issues pertaining to North Sea fishing are beyond the scope of this section and will be covered in more detail in report 5 Management.

The large distance to be travelled from the coast, the exposed offshore location and the inhospitable climate will discourage the use of an artificial reef at Ekofisk for sports fishing. The pressure on fish stocks from sports fishing, such as that exerted on the platform reefs of the Mexican Gulf, will not be great, and most likely, non-existent.

4.5.4 Evaluation

Inevitably, much of the predictions of possible socio-economic impacts will be speculative due to the lack of available data. According to Milon (1991) little regard has been paid in the literature to the socio-economic impacts of artificial reefs. By way of compensation Milon (1991) provided a thorough review of the methods by which such impacts may be assessed, for example, cost-benefit analyses and their associated parameters of present value, internal rate of return and pay-back. The whole process of reef siting and construction was taken into account and the question of where the baseline should be drawn was posed. Should artificial reefs be evaluated as a cost-efficient form of decommissioning, or on the basis of the external benefits (costs) they may generate? It was considered important to identify the objectives and the relevant users at whom these objectives are aimed. Increasing, for example, the biomass by 25 % for the benefit of community in the most cost-effective way.

Deciding whether a reef project should be undertaken naturally involves valuation. This includes the pricing of inputs and outputs of a project (after denoting them in physical terms) and assessing the value of non-tradeable and/or non-tangible goods (e.g. goodwill). Whitmarsh *et al.* (1996) studied an artificial reef off the English coast, and its impact on lobster production. The study provides useful guidelines. It produced estimates of the net present value and internal rate of return, as well as taking into account risk and uncertainty through probability distributions of the range of likely outcomes. Such studies of North Sea platform reefs can be performed once the required data is obtained.

The data needed to conduct a successful evaluation comprises:

- estimates of fish stock in the fishing area to which the reef is associated (central North Sea);
- estimates of the catchable stock within the reef;
- the size of the fishing fleet in the area;
- the components of an average catch, and the time spent to achieve it;
- the prevailing market price of individual fish types.

4.5.5 Socio-economic impacts of debris

One specific long-term problem associated with the establishment of platform reefs is the potential for the build-up of debris on the sea-floor. This debris could then prove a safety risk at worst, and/or a hindrance with economic implications for fishermen. The risk of debris impacting the fishing industry would be expected to increase with increasing quantities of debris and with an increase in the area covered by such items.

In section 3.5.5 an attempt was made to estimate the likely build-up of debris on the sea-floor and its spread, as a result of the gradual degradation of the reef. It was considered likely that the structures would be sufficiently integral to continue to function as reefs for a period of 135 years after placement. Once the anodes had been exhausted, corrosion would proceed at a faster rate, and after 75 % of the effective cross-member have corroded away, total collapse would be expected.

There is some potential for smaller pieces of debris to be moved by bottom currents or by the actions of the fishing industry itself. It was concluded that after collapse of the platform structure, there would be a quantity of corroding steel debris on the sea-floor. The extent of this debris was considered unlikely to give rise to anything other that a localised effect. The spreading of debris would be hindered by other pieces of debris, and by protrusions becoming embedded in the sediment, The debris site would need to continue to be marked as it was when the reef was integral, whilst the objects continued to corrode and become buried in the sediment. This estimate was however based on little or no hard data, as no relevant results are currently available.

Bottom trawling fishermen are at the greatest risk of encountering bottom debris. These wide-mouthed trawl nets are dragged along the sea-floor for several kilometres at a run. Depending on the size of the object snagged, the power of the vessel and its stability, there is a risk of severe, or even catastrophic damage either to the gear, or more seriously, to the boat itself (capsizing), and therefore crew.

It is presumed that the position of the artificial reef will have been marked, both on-site and on nautical maps for the 100 + years prior to structural collapse. There should therefore be a long tradition of avoiding using bottom trawls in the area. It should be noted that there are many ship wrecks in the North Sea that, whilst they present a risk of snagging, often offer the opportunity for enhanced fishing. Once located they are usually avoided.

It is considered that the spread of debris is a more important consideration that the build-up of debris in one limited area. Should debris move around on the sea-floor, then it would be difficult to mark its position and so consequently the risk of snagging would be greater. The risk of debris transport can be reduced by choosing a reef creation Alternative that collects several structures at one, or a few, limited sites. The use of only large structures, possibly anchored, further reduces the probability of debris migration. By the time such large structures have broken down to a size that may be moved by bottom currents, they will be substantially corroded, partially or wholly buried, and entangled in other debris. For these reasons, the debris from ship-wrecks (as opposed to the wreck itself) has not commonly been considered a problem for fishermen.

A further possible long-term impact of debris creation on fishing economics is the area is that of lost fishing grounds under the debris. The concept of limited access, when applied to such small areas, is though an over-simplification that assumes that the fish will remain uncatchable in the debris zones throughout their lives. This is not correct and so no long-term negative consequences are expected as a result of lost grounds.

In summary then, piles of debris are expected at artificial reef sites after more than 100 years, but these are unlikely to be extensive in area, so the negative socio-economics impacts of debris on fishermen are not expected to be great. Indeed, benefits are expected because the debris may continue to function in a limited capacity as artificial reefs after collapse.

4.5.6 Summary of socio-economic impacts

It can then be concluded that some socio-economic impacts may result from the construction of Ekoreef. These impacts are likely to be limited due to the remote location of Ekofisk, the few alternative users and the small size of the area concerned in relation to the North Sea as a whole. Impacts will mainly be confined to the fishing and fish processing industries. Generally the impacts are positive, though there is insufficient information available to quantify them reliably.

The following is a list of possible socio-economic impacts, to be combined with the environmental impacts described previously. Impacts such as increased fish production, that have been covered previously will not be duplicated here.

24. *Operating company reputation.* If handled well this will be a positive impact, showing the company to have chosen an environmentally acceptable option compared with other options such as deep-sea dumping or land disposal. If handled badly this could be viewed as an excuse to dump redundant material and avoid paying the cost of clearing up after use.

25. *Reduced catch effort.* The time taken, and therefore effort expended, to catch the target quantity of fish can be reduced by fishing the denser shoals around a reef. Catch is not increased, but more time is available for other activities.

26. *Increased catch.* If fishing effort is maintained constant, reefs can potentially be used to gain a larger catch as a result of their aggregating function. Larger catches can result in the increased employment, though the high start-up costs tend to limit newcomers. Increased catches are far from certain and need to be quantified. Quota regulations are currently strongly enforced so this is unlikely to be a viable consequence.

27. *Improved catch security.* The certainty with which the target quantity of fish are caught can theoretically be increased by reefs. This would result in a more stable income for the fisherman.

28. *Improved process planning.* By producing a more stable supply of fish, storage requirements could be reduced and quality, through freshness, improved. The market pays premium rates for predictable, high quality supplies.

29. *Changes in gear requirements.* In order to exploit the fishing potential of a reef, specialist, or at least different gear may be required. There may, for example, be a need to use long lines instead of bottom trawls. This will in turn be a benefit for the environment as more damaging methods, such as trawling, may be restricted. There may though be a cost for the fishermen.

30. *Gear damage.* Fishing close to large structures is inherently risky, because gear, such as nets or lines may become entangled and either damaged or lost. The design of the reef and the proximity of the fish to the reef will influence how near to the reef the fishermen work. The quantity of debris, and more importantly its spread on the sea-floor, is likely to have a localised effect on gear damage.

31. *Safety.* This is a major issue for fishermen. Entanglement of nets can be a danger to crew and has often led to the loss of the boat. Generally fishermen, especially bottom trawlers, would prefer a clean, featureless sea-bed over which to work. Any structures remaining after cessation must be clearly marked on-site and on maps. Again the design of the reef, the structures used, the quantity and spread of debris, and behaviour of the fishermen will greatly influence safety.

32. *Limited access.* Management of the reef, to optimise catches or protect stocks may need to restrict the length of time (fishing effort) on the reef. The legality of this is uncertain within current fishing agreements in the region.

33. *Limited fishing groups.* The concept of allowing only specific groups of fishermen access to a reef has been suggested. Such co-operatives could control, manage and safeguard a reef. They would have an interest in sustainable fishing. Alternatively some groups would then be excluded, probably leading to conflict. Again the legality of this is uncertain within current fishing agreements in the region, though the EU is reviewing its Common Fisheries Policy, and such concepts are being considered.

The possible socio-economic impacts of Ekoreef are summarised in Figure 4.3.

***Figure 4.3**: Summary of possible socio-economic impacts*

4.6 Other possible impacts

Several other impacts could possibly occur, but by no means all are likely to any realistic extent.

34. *Shipping.* The reefs must not be a dangerous hindrance to shipping. Whilst reef creation may be defined as an alternative re-use of the petroleum structures, and as such they will not be covered under the 55 m free-space requirement of the IMO regulations, they need to be at sufficient depth to avoid collision with deep draught vessels. Structures remaining on the surface, such as the Ekofisk Tank will need to be clearly marked. The location of even submerged structures will need to marked on maritime charts. Submarine collision is unlikely, but possible. The subject of continued liability for the operator is relevant, but falls outside of the scope of this report (see impact 37).

35. *Damage to operating structures.* Reef implementation operations could represent a risk to operating structures. Techniques such as leg cutting, toppling, transportation and placement may need to be conducted in the vicinity of operating structures. The obvious risks, of primarily collision, will need to be minimised. Decommissioning may need to be delayed in an area in order for all neighbouring platforms to stop production.

36. *Damage to pipelines.* Structures must be placed so that they do not lie on and damage functioning pipelines. Some areas around Ekofisk have a dense network of pipelines with various functions. Damage to decommissioned pipelines may result in some pollution release.

37. *Stabilisation of pipelines.* Alternatively, platform structures could be used to stabilise decommissioned pipelines. Again care should be taken avoid damage such pipelines during placement.

38. *The safety of reef implementation.* Several potentially risky operations are involved in the creation of reefs from platforms. As stated above, these include, but are not limited to, leg cutting, toppling, heavy lifts, transport and placement. Diver intervention will no doubt be avoided and controlled toppling will be aimed for. Some development of new techniques will be required. A review of safety is outside of the scope of this report.

39. *Operator liability.* As long as the structures remain on-site, they may be considered to be the liability of the original operators. A legislative decision on this matter needs to be taken by the relevant national governments. If liability remains, there will be a continued economic and public opinion risk for operators with potentially large economic consequences. Shipping collisions and fishing net damage are two potential areas of conflict. Should a reef be taken over by another group, such as a fisherman's co-operative, then it may be possible to transfer liability.

These miscellaneous impacts are summarised in Figure 4.4.

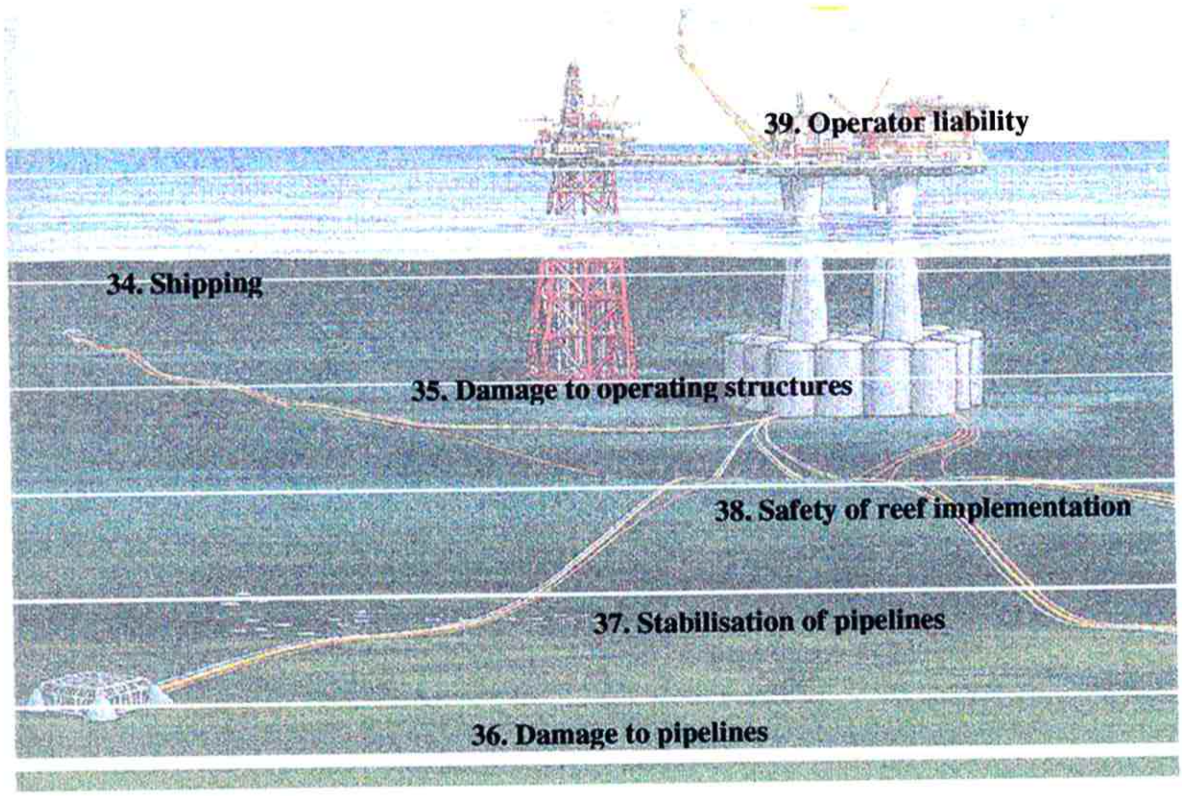

***Figure 4.4**: Summary of possible miscellaneous impacts*

4.7 Impact reduction or optimisation

Table 4.2 summarises an attempt to semi-quantitatively assess the scale of possible positive and negative impacts arising from the establishment of Ekoreef in general. The impact score has been based on criteria defined in Table 4.1. Additionally Table 4.1 indicates techniques that could be employed to reduce negative impacts and maximise or optimise positive impacts. The possible scale of effects that these techniques would have is also assessed (column 6) as an aid to planning and management.

***Table 4.2a**: Summary of impact types, their relative importance and techniques for reducing negative impacts or maximising positive benefits.*

No.	Impact	Positive/negative (Table 4.1)	Type - operational/ long/ short term	Reduction/optimisation	Potential for improvement
	Impacts on the exploitable stock				
1	Redistribution of biomass	+3	Long	Max. complexity, increase size, cluster.	Large
2	Increased exploitable biomass	+2/+1	Long	As 1. Design accessible to fishermen.	Large
3	Increased production	0	Long	As 1. Design for protection.	Small
4	Reduced mortality	+1	Long	As 3.	Some
5	Growth overfishing	0	Long	Design for protection. Enforce current minimum size regulations.	Large
6	Recruitment overfishing	-1	Long	Manage / restrict reef fishing effort.	Large
7	Changes in predator mortality	-1	Long	Crop large fish.	Some
8	Tainting / contamination	-1	Short	Avoid contaminated sites / cuttings piles.	Large
	Impacts on the local biota				
9	Changes in epifauna species	+ 2 (-2?)	Long	As 1. Provide range of depths and niches.	Some
10	Increase in the epifauna biomass	+2	Long	As 9.	Some
11	Changes in infauna	-1	Short	Locate with respect to prevailing current.	Small
12	Smothering	-1	Operational	Use open structures, avoid relocation/drifting.	Small
13	Changes in bio-fouling	0	Short	Allow populations to re-stabilise	Small
14	Contamination of fauna	-1	Short	As 8.	Large
15	Infauna predation	-1	Long	Use high profile reefs with low surface area to attract pelagic rather than demersal fish (not desired)	Small

***Table 4.2b**: Summary of impact types, their relative importance and techniques for reducing negative impacts or maximising positive benefits.*

No.	Impact	Positive/negative (Table 4.1)	Type - operational/ long/ short term	Reduction/optimisation	Potential for improvement
	Impacts on the sediment				
16	Resorting	-2	Short	Place reef carefully, avoid contaminated sediments / cutting piles.	Some
17	Scouring / deposition	-1	Short	As 16	Some
18	Sediments contamination	0	Short	Clean and prepare structures.	Large
19	Debris	-2	Long	Use only large, stabile, high integrity structures. Limited number of reef sites.	Large
	Impacts on the water column				
20	Flow changes	+3	Long	As 1. Increase high profile.	Small
21	Water column contamination	0	Short	As 18.	Large
	Energy and emissions				
22	Energy usage	-1	Operational	Minimise transport and lifting operations.	Large
23	Gaseous emissions	-1	Operational	As 22	Large
	Socio-economic impacts				
24	Operating company reputation	-2 to +3	Long	Open discussion. Stakeholder involvement. Show alternatives are being considered.	Large
25	Reduced catch effort	+1	Long	Manage fishing effort on reef. Design for fishing.	Some
26	Increased catch	0	Long	As 25.	Small
27	Improved catch security	+1	Long	As 25.	Some
28	Improved process planning	+1	Long	As 25.	Small

***Table 4.2c**: Summary of impact types, their relative importance and techniques for reducing negative impacts or maximising positive benefits.*

No.	Impact	Positive/negative (Table 4.1)	Type - operational/ long/ short term	Reduction/optimisation	Potential for improvement
29	Changes in gear requirements	-1	Long	Design reef for trawling.	Large
30	Gear damage	-2	Long	Avoid debris and sharp ends. Design for defined area. Mark zone.	Some
31	Safety	-2	Long	As 30	Some
32	Limited access	-1 (fishermen) +1 (fish stocks)	Long	Design reef for protection. Influence legislation.	Some
33	Limited fishing groups	-1 / +1	Long	As 32. Implement a co-operative concept.	Some
	Other possible impacts				
34	Shipping	0	Long	Ensure sufficient depth. Mark & publicise.	Large
35	Damage to operating structures	-2	Operational	Use proven technology. Plan for decommissioning in stages.	Large
36	Damage to pipelines	-1	Operational	Plan location. Avoid transport over important pipelines.	Large
37	Stabilisation of pipelines	+2	Long	Plan location. Careful placing.	Large
38	The safety of reef implementation	-1	Operational	As 35. Avoid diver intervention.	Large
39	Operator liability	-2	Long	Influence legislation to restrict liability. Transfer ownership.	Some

4.8 Impacts of the reef configuration alternatives

4.8.1 Reef creation scenarios

The follow section summarises the options for reef creation proposed in report 3 Configuration. A more detailed description of each scenario is presented in that report.

Alternative 1 (Centre): A single complex reef will be created around the Ekofisk Tank using structures as they become available, until all of the platforms are decommissioned after 2028.

Alternative 2 (Tank, Eldfisk): A reef will be created north-west of the Ekofisk Tank using platforms decommissioned before 2005. A second reef will be created at Eldfisk 2/7-B using platforms decommissioned after 2005.

Alternative 3 (Centre, Tank): A reef will be created at Ekofisk B/K containing structures that will be decommissioned before 2005. The reef will be expanded at the Ekofisk Tank and a second reef complex created with platforms decommissioned after 2005.

Alternative 4 (Albuskjell, Eldfisk): A reef will be created at Albuskjell 1/6-A using platforms decommissioned before 2005. A second reef will be created at Eldfisk 2/7-B using platforms decommissioned after 2005.

Alternative 5 (Albuskjell, Tank): A reef will be created at Albuskjell 1/6-A using platforms decommissioned before 2005. The reef will be created at the Ekofisk Tank and a second reef complex created with platforms decommissioned after 2005.

Alternative 6 (In situ toppling): All platforms at the Greater Ekofisk Field will be toppled in-place as they become decommissioned.

Within Alternatives 1 - 5, there is both a habitat protection (p) and an enhanced fishing design (f). A total of 11 alternatives are therefore visualised and presented as potential scenarios. For stock protection the structures will be positioned in one or more circles. For assisting fishing, the structures will be positioned linearly, thus allowing trawler activity and maximum access to the reefs.

4.8.2 Assignment and ranking of impacts

The following Table 4.3 indicates which impacts could possibly occur as a result of the different alternatives. An attempt is also made to semi-quantitatively assess the scale of any potential impact, in the form of impact severity scores, also shown in Table 4.3.

***Table 4.3a**: Assessment of the scale of impacts that may occur as a result of the different alternatives.*

Impacts		Alternatives										
No.	Description	1-Centre		2-Tank+Eld		3-Centre+Tank		4-Alb+Eld		5-Alb+Tank		6-Top
		p	f	p	f	p	f	p	f	p	f	--
	Impacts on the exploitable stock											
1	Redistribution of biomass	+3	+2	+3	+2	+3	+2	+3	+2	+3	+2	+1
2	Increased exploitable biomass	+1	+2	+1	+2	+1	+2	+1	+2	+1	+1	+1
3	Increased production	0	0	0	0	0	0	0	0	0	0	0
4	Reduced mortality	+2	+1	+2	+1	+2	+1	+2	+1	+2	+1	+1
5	Growth overfishing	0	-1	0	-1	0	-1	0	-1	0	-1	0
6	Recruitment overfishing	0	-1	0	-1	0	-1	0	-1	0	-1	0
7	Changes in predator mortality	-2	-1	-2	-1	-2	-1	-2	-1	-2	-1	-1
8	Tainting / contamination	-1	-1	-1	-1	-1	-1	0	0	-1	-1	-1
	TOTAL exploitable stock	**+3**	**+1**	**+3**	**+1**	**+3**	**+1**	**+4**	**+2**	**+3**	**0**	**+1**

***Table 4.3b**: Assessment of the scale of impacts that may occur as a result of the different alternatives.*

Impacts		Alternatives										
No.	Description	1-Centre		2-Tank+Eld		3-Centre+Tank		4-Alb+Eld		5-Alb+Tank		6-Top
		p	f	p	f	p	f	p	f	p	f	--
	Impacts on the local biota											
9	Changes in epifauna species	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2
10	Increase in the epifauna biomass	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2
11	Changes in infauna	-1	-1	-1	-1	-1	-1	0	0	-1	-1	-1
12	Smothering	-1	-1	-1	-1	-1	-1	0	0	-1	-1	-1
13	Changes in bio-fouling	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
14	Contamination of fauna	-1	-1	-1	-1	-1	-1	0	0	-1	-1	-1
15	Infauna predation	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
	TOTAL biota impacts	**-1**	**-1**	**-1**	**-1**	**-1**	**-1**	**+2**	**+2**	**-1**	**-1**	**-1**

Table 4.3c: *Assessment of the scale of impacts that may occur as a result of the different alternatives.*

Impacts		Alternatives										
No.	Description	1-Centre		2-Tank+Eld		3-Centre+Tank		4-Alb+Eld		5-Alb+Tank		6-Top
		p	f	p	f	p	f	p	f	p	f	--
	Impacts on the sediment											
16	Resorting	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
17	Scouring / deposition	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
18	Sediments contamination	-2	-2	-1	-1	-2	-2	0	0	-1	-1	-2
19	Debris	-2	-3	-2	-3	-2	-3	-2	-3	-2	-3	-3
	TOTAL sediment impacts	**-7**	**-8**	**-6**	**-7**	**-7**	**-8**	**-5**	**-6**	**-6**	**-7**	**-8**
	Impacts on the water column											
20	Flow changes	+2	+3	+2	+3	+2	+3	+2	+3	+2	+3	+2
21	Water column contamination	0	0	0	0	0	0	0	0	0	0	0
	TOTAL water column	**+2**	**+3**	**+2**	**+3**	**+2**	**+3**	**+2**	**+3**	**+2**	**+3**	**+2**
	Energy and emissions											
22	Energy use	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0
23	Gaseous emissions	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0
	TOTAL energy and emissions	**-2**	**-2**	**-2**	**-2**	**-2**	**-2**	**-2**	**-2**	**-2**	**-2**	**0**

***Table 4.3d**: Assessment of the scale of impacts that may occur as a result of the different alternatives.*

Impacts		Alternatives										
No.	Description	1-Centre		2-Tank+Eld		3-Centre+Tank		4-Alb+Eld		5-Alb+Tank		6-Top
		p	f	p	f	p	f	p	f	p	f	--
	Socio-economic impacts											
24	Operating company reputation	?	?	?	?	?	?	?	?	?	?	?
25	Reduced catch effort	+1	+2	+1	+2	+1	+2	+1	+2	+1	+1	0
26	Increased catch	0	0	0	0	0	0	0	0	0	0	0
27	Improved catch security	0	+1	0	+1	0	+1	0	+1	0	+1	0
28	Improved process planning	0	+1	0	+1	0	+1	0	+1	0	+1	0
29	Changes in gear requirements	-1	0	-1	0	-1	0	-1	0	-1	0	-1
30	Gear damage	-1	-3	-1	-3	-1	-3	-1	-3	-1	-3	-2
31	Safety	-1	-3	-1	-3	-1	-3	-1	-3	-1	-3	-2
32	Limited access	-2	0	-2	0	-2	0	-2	0	-2	0	-2
33	Limited fishing groups	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
	TOTAL socio-economic	**-5**	**-4**	**-6**	**-4**	**-6**	**-4**	**-6**	**-4**	**-6**	**-5**	**-9**

***Table 4.3e**: Assessment of the scale of impacts that may occur as a result of the different alternatives.*

Impacts		Alternatives										
No.	Description	1-Centre		2-Tank+Eld		3-Centre+Tank		4-Alb+Eld		5-Alb+Tank		6-Top
		p	f	p	f	p	f	p	f	p	f	--
	Other possible impacts											
34	Shipping	0	0	0	0	0	0	0	0	0	0	0
35	Damage to operating structures	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-1
36	Damage to pipelines	-2	-2	-2	-2	-2	-2	0	0	-2	-2	-2
37	Stabilisation of pipelines	+1	+1	+1	+1	+1	+1	0	0	+1	+1	+1
38	The safety of reef implementation	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-1
39	Operator liability	-2	-3	-2	-3	-2	-3	-2	-3	-2	-3	-3
	TOTAL other impacts	**-8**	**-9**	**-8**	**-9**	**-8**	**-9**	**-7**	**-8**	**-8**	**-9**	**-6**

4.8.3 Comparisons between the alternative reef scenarios

Having semi-quantitatively assessed the seriousness of any potential negative or positive impacts, the scores within each group of impacts can be added together and summarised in the following Table 4.4. This will then permit the impacts of the different alternatives to be compared and a tentative ranking of these impacts can be calculated to assist in the decision-making process. It should be noted that no weighting is apportioned to any of the group sums, e.g. safety aspects are considered equally to environmental concerns. The reader can then weigh the results according to their own criteria.

***Table 4.4**: Total impact scores and relative ranks for the various Alternatives.*

Impacts		Alternatives										
No.	Description	1-Centre		2-Tank+Eld		3-Centre+Tank		4-Alb+Eld		5-Alb+Tank		6-Top
		p	f	p	f	p	f	p	f	p	f	--
1-8	Impacts - exploitable stock	+3	+1	+3	+1	+3	+1	+4	+2	+3	0	+1
1-8	Rank - exploitable stock	2	10	2	7	2	7	1	6	2	11	7
9-15	Impacts - local biota	-1	-1	-1	-1	-1	-1	+2	+2	-1	-1	-1
9-15	Rank - local biota	3	3	3	3	3	3	1	1	3	3	3
16-19	Impacts - sediment	-7	-8	-6	-7	-7	-8	-5	-6	-6	-7	-8
16-19	Rank - sediment	5	9	2	5	5	9	1	2	2	5	9
20-21	Impacts - water column	+2	+3	+2	+3	+2	+3	+2	+3	+2	+3	+2
20-21	Rank - water column	6	1	6	1	6	1	6	1	6	1	6
22-23	Impacts - energy and emissions	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0
22-23	Rank - energy and emissions	2	2	2	2	2	2	2	2	2	2	1
24-33	Impacts - socio-economic	-5	-4	-6	-4	-6	-4	-6	-4	-6	-5	-9
24-33	Rank - socio-economic	5	1	7	1	7	1	7	1	7	5	11
34-39	Impacts - other	-8	-9	-8	-9	-8	-9	-7	-8	-8	-9	-6
34-39	Rank - other	3	8	3	8	3	8	2	3	3	8	1
1-39	TOTAL IMPACTS	-18	-20	-18	-19	-19	-20	-12	-13	-18	-21	-21
1-39	OVERALL RANK	3	8	3	6	6	8	1	2	3	10	10

4.9 Impacts discussion

4.9.1 Scoring and ranking procedure

Care must be taken not to over-quantify the results of the impact scores for each reef creation Alternative. At this early stage of the decision-making process, the aim of such a procedure is to use the scores as a means to identify Alternatives that would be expected to have less, or more, impacts than others, not as a precise measure of impacts. The procedure is then primarily comparative. At a later stage in platform reef implementation, a more detailed, quantifiable impact assessment can be conducted for the chosen Alternative, assuming Ekoreef is the chosen decommissioning option.

In order to avoid an over-emphasis on small differences in impact scores, discussions and conclusions have been based mainly on ranking. The highest ranking options (lowest number) are those with the most positive or least negative impacts.

It can been seen in Table 4.4 that many of the impacts did not vary greatly between the different Alternatives. Thus it was the action of reef creation, rather than the specific conditions of an Alternative, that resulted in the majority of impacts.

4.9.2 Exploitable stock

Scores. Ranged between 0 and +4. All were positive, indicating that this category of impacts contained the main benefits of platform reefs.

Rank. The protection options were all ranked higher than fishing options, with Alternative 4 scoring most positive.

Basis for result. Alternative 4 differed only slightly from others because of the small risk of contamination of stocks at the other locations.

Conclusions. Reefs constructed for protection may give the most benefits in terms of stock enhancement.

4.9.3 Local biota

Scores. Ranged only between -1 and +2. Negative operational impacts on local animals slightly outweighed benefits from fouling organisms. This may have been due to the larger number of categories in the former group.

Rank. All Alternatives were ranked similarly, with the exception of Alternative 4 scoring most positive.

Basis for result. Alternative 4 differed slightly from others because of the risk of contamination restricting the distribution of animals at the other locations.

Conclusion. A clean site would be preferable from an ecological perspective.

4.9.4 Sediment

Scores. Ranged only between -5 and -8, showing that some negative impacts on the sea-floor are expected.

Rank. Compactly designed protection options were generally higher ranked than more expansive fishing reef designs options.

Basis for result. Alternative 4 was again highly ranked because of the risk of locating reefs in contaminated sediments at the other sites.

Conclusions. If short-term operation impacts are to be minimised, a clean sea-floor would be preferable. Compact reefs may have less negative impacts than extensive reefs.

4.9.5 Water column

Scores. Ranged only between +2 and +3 indicating that it was reef creation itself that was the cause of any disturbance.

Rank. Fishing options were ranked slightly higher because of the greater positive disturbance their extensive design caused.

Basis for result. Compact protection reefs presented a smaller surface area to the prevailing currents.

Conclusion. Extensive reef designs may disturb the water column greatest, allowing entrainment of commercial fish and food species, though this has not been proved.

4.9.6 Energy and emissions

Scores. Ranged only between 0 and -2 because these impacts were considered operational and hence extremely short-term in relation to the life-time of the reef.

Rank. The topple *in situ* was ranked highest because of the relative ease (in terms of energy consumption) that the platforms could be positioned without the need for lifting or transport.

Basis for result. With the exception of the topple *in situ* option, energy costs and hence emissions were similar (see Appendix 3.2) and lasted only during the implementation operations.

Conclusion. Complex reefs that are composed of structures requiring the minimum of lifting and transport will require the least energy to build and hence the least gaseous emissions.

4.9.7 Socio-economics

Scores. Ranged between -5 and -9 and hence contained the largest negative impacts, partly due to the large number of categories.

Rank. Fishing options were ranked highest and toppling *in situ* the lowest.

Basis for result. Fishing reefs are designed to maximise benefits for fishermen and minimise fishing ground hindrance.

Conclusion. Reefs planned to assist fishermen to fish give the greatest socio-economic benefits.

4.9.8 Miscellaneous

Scores. Ranged only between -6 and -9. Many of the scores were highly positive, indicating the importance of safety and liability in evaluating reef creation.

Rank. Toppling *in situ* scored best in this category and expansive fishing reefs scored least.

Basis for result. Safety of creation, i.e. without the need to dislocate and transport to another site, was of major importance.

Conclusion. Toppling *in situ* may well be the safest and cheapest Alternative available. As these factors are paramount this result can be considered important.

4.9.9 Overall

Scores. Ranged between -12 and -21 showing that this report dealt mainly with the negative aspects whilst other reports (report 5, *Management*) considered the benefits in more detail. All 5 of the protection options scored less negatively than the corresponding fishing options of each Alternative, though in 4 out of 5 cases the scores only differed by a value of 1 or 2 .

Rank. Both the protection and fishing options of Alternative 4 were clearly ranked highest, whilst toppling *in situ* clearly ranked lowest. As stated above, the protection option of each Alternative ranked higher than the corresponding fishing options.

Basis for result. Within the environmental categories, the scores of protection options were greater than, or very similar to, their corresponding fishing option. The final totals did not reflect this difference because the scores were partially redressed by the bias towards the fishing options shown by the socio-economic impacts. With the exception of energy and emissions, and safety and liability, the toppling *in situ* Alternative scored badly in all categories.

Conclusions.

1. From an environmental and ecological (including commercial fish stocks) perspective, the use of reefs for protection would seem to be a better option than use for commercial fishing. Differences in impacts between these two options were though not great.

2. Alternative 4, Albuskjell and Eldfisk, was clearly the best option overall. This could have been due to an over-estimate of the different vectors for contaminants in the sediments to be transferred into the environment. Whilst it is considered that the risk of long-term contamination of the biota or surrounding environment is unlikely to occur, other than during the operation of locating the platform at the reef site, there are several ways that this pollution could occur. Hence contamination is, somewhat artificially, scored in several ways.

3. This impact assessment has been conducted under the assumption that the sea-bed will be left, after decommissioning, in the condition it was in during operation, i.e. 1997. Cuttings piles have then assumed to have been left in place. Should these be removed, it would be expected that the long-term risk of contamination would be reduced, and hence more centrally located reef sites such as the Tank and the Centre complex, would score less negatively in respect of contamination.

4. With the exception of Alternative 6, the other Alternatives, 1, 2, 3 and 5 scored similarly and hence no reliable difference could be determined as an aid to the choice of a final strategy.

5. From an environmental and socio-economic perspective, Alternative 6, toppling *in situ* was the worst Alternative. With the exception of the energy and emissions and socio-economics categories, scores for this Alternative did not differ greatly from others, though the cumulative difference of all the categories was significant. Though it is outside the remit of this study, it was considered the safest option and the cheapest to implement. These parameters may outweigh others, hence the Alternative is still considered viable.

6. It may be possible to include smaller non-jacket structures in the designs of artificial reefs, but these must be chosen and incorporated with care so as to avoid the production and transport of sea-floor debris that would be a safety risk for trawler fishing activities.

7. Irrespective of small impact score differences between particular options and Alternatives, the benefits of a protection strategy appear to outweigh those of a fishing strategy (Figure 4.5). Similarly, the impacts of locating the reefs at relatively clean sites at Albuskjell and Eldfisk appear to be less than those at sites where there has been heavier offshore industry activity.

8. Combining the two conclusions in the previous point, indicates the following order of preferences from an environmental and socio-economic perspective:

    1) Protection reefs at Albuskjell and Eldfisk would be optimal.

    2) Protection reefs at any of the other complex reef sites.

    3) Fishing reefs at Albuskjell and Eldfisk.

    4) Fishing reefs at any of the other complex reef sites.

    5) Non-specified usage reefs as a result of toppling *in situ* is least optimal, but has other important related advantages.

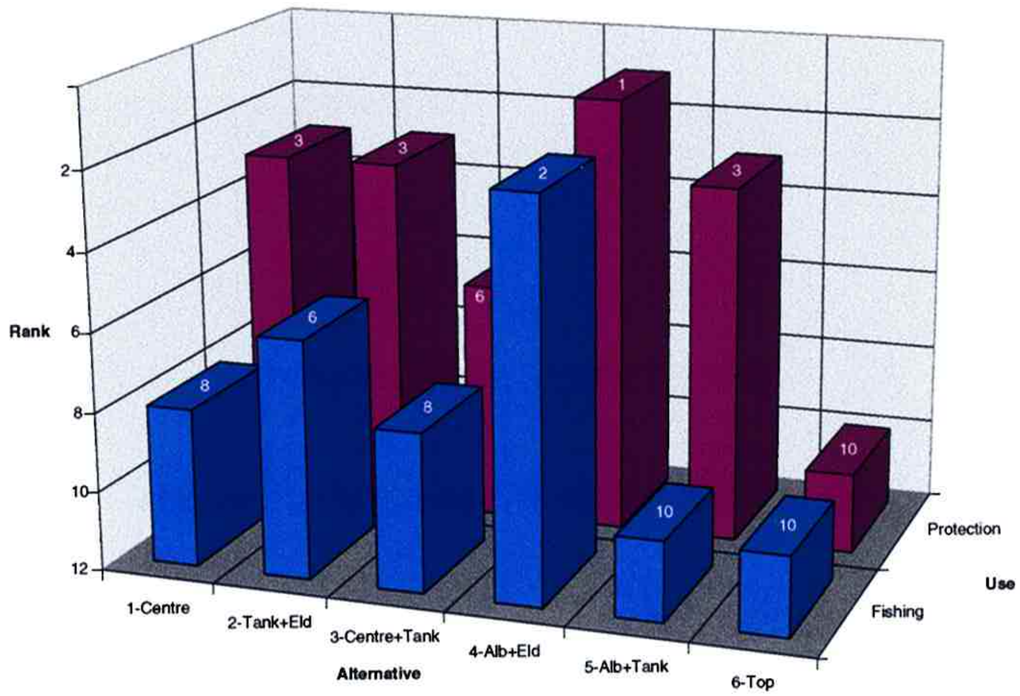

***Figure 4.5**: Ranking of overall sums of the impact scores for each reef creation Alternative.*

4.10 Waste management

4.10.1 Introduction

Prior to reef creation, toxic, loose and unsuitable material on the jacket structures must be removed and handled in an appropriate way. In order to gather information for the waste management and a logical flow through the process of dismantling and recycling of an offshore jacket including the Module Support Frames (MSFs), the waste management plan proposal will contain the following considerations:

- baseline determination of conditions offshore including a register of material;
- waste management and risk considerations.

4.10.2 Assumptions and limitations

- For material identification purposes, the starting point of reference is a steel jacket installation that has reached the end of its useful production life at its current location, has been rendered in a cold state (i.e. hydrocarbon free) following draining down of the systems, and plugging and abandonment of the wells.
- Waste management for topside modules are not considered in this Ekoreef project and are outside the scope of this work.
- The MSFs are discussed, and are in this report considered together with the jackets, because of their structural similarity and potential for being part of an artificial reef.
- The waste management of the cutting piles are not discussed here, since it is discussed in section. 3.3.2.6. Drill cuttings disposal options.

4.10.3 Baseline determination of conditions offshore and register of materials on the jacket structure

Decommissioning should include the removal, as far as practicable, of "listed materials" from the jacket legs and MSFs, to comply with legislative requirements. This would involve flushing the process system, probably entry into larger vessels to remove residual sand, sludge and scale and, in some cases, removal of equipment. Following flushing, it would be necessary for residual materials to be contained, and transported to onshore treatment facilities.

The material destined for onshore re-use, re-cycling or disposal will be transferred to barges or towed to shore. In this case, the main sources of impact will be the leakage of contamination as vessels and pipe-work are dismantled, or accidental loss of material during the lifting, transport and transfer to onshore locations.

4.10.3.1 Register of materials on the jacket structures

This section provides a materials breakdown for the residual materials inventory for the 'reference' installation. The materials breakdown are only for the jacket structures, including the MSFs and are based on both published sources and on previous work undertaken by Dames & Moore (1996).

No attempt has been made to provide a definitive assessment of the quantities of these materials. An overall estimate of the residual materials is provided in Table 4.5 below.

Table 4.5: *Guidelines for a Recommended Framework Procedure. (Source: Dames & Moore 1996).*

Category	Main Source	Principal Component	Recommended Practice	Comment
Heavy Metals	Anodes	Al, Zn	Assess anode consumption rates. Leave on structure or remove from part of structure in photic zone.	Rate of dissolution of Al and Zn from anodes slow. Bioavailability potential of Al low. Zn is an Annex II (London & Oslo Convention) & Annex III (OSPAR Convention) substance. Removal of anodes in-situ would be costly & time consuming. However, anode metals are recyclable.
	Plated Bolts	Cd	Leave on structure.	Rate of dissolution of the metal species would be slow. Cd is an Annex I (London & Oslo Conventions) and Annex III (OSPAR substance).
	Paints & coatings on structures	Pb, Zn, Cu	Leave on structure.	Rate of dissolution of Cu, Zn & Pb from the paints & Coatings would be slow. The paints and coatings may inhibit the natural rate of colonisation of biofouling organisms. Cu, Pb & Zn are Annex II (London & Oslo Conventions) & Annex III (OSPAR Convention) substances.
	LSA Scale	Ba, Sr (Barium, Strontium & Calcium sulphate & Calcium Carbonate)	Remove using mechanical methods for both hard scale and soft scale in sediments. Alternatively the pipes etc. can be removed & taken to shore for de-scaling or disposed of offshore down a disused well. (Refer to Radioactive Material category below)	Hard scale will be adhered to the internal surfaces of pipes, vessels & other process equipment.
Radioactive materials	Process pipework, tubulars etc.	LSA scale (Radium 226, Actinium 238 & progeny)	Remove. Evaluate on a case by case basis with respect to the level of radiation. Either remove contaminated equipment or mechanically clean offshore. Both equipment and wastes could be disposed of down a disused well during plugging and abandonment.	The scale is highly insoluble thus dissolution would be slow. However, NORM material released into the environment would have a tendency to bioaccumulate. Radioactive substances are Annex I (London Convention) and Annex III (OSPAR Convention) substances. Radioactive substances are not subject to the same exemption conditions as other substances. However, de minims levels of radioactivity are exempt from the prohibition on disposal.
Other Materials	Gaskets, pipework, insulation, bulkhead insulation.	Asbestos	Remove as far as practical following asbestos survey to confirm condition. Asbestos material may require encapsulation prior to removal.	Asbestos is highly insoluble in water, however it will be present in marine water as suspended fibres especially if damage to the material is incurred. It would be costly & time consuming to attempt to remove each asbestos containing gasket from process equipment, there would also be substantial access limitations. However, where asbestos is present in fire walls it would be feasible to remove the material.
Oslo Convention: Annex I substances - dumping prohibited; Annex II Substances - requirement for Specific prior permit for the dumping of wastes containing 'significant quantities of Annex II substances. London Convention: Annex I substances - dumping prohibited except where such substances 'are rapidly rendered harmless'.. or are contained in wastes or other materials as 'trace contaminants' ; Annex II substances - requirement for a prior Special permit - described as substances requiring special care.				

4.10.3.2 Assessment of material removal

It is assumed that the operator will be required to remove, to onshore, as far as practicable, all "listed" materials from a jacket platform, including the MSF's prior to its disposal, irrespective of the option for disposal selected. The two primary factors for handling of such materials that need to be considered are:

- The "listed materials" that represent a potential hazard to the environment will require special attention in terms of their disposal:

  - offshore at the platform site during decommissioning and reverse installation;

  - during transfer to transport vessels and subsequent transport to shore; and

  - onshore during transfer and dismantling.

- Some of the "listed materials" (e.g. PCBs, biocides, oils) and others which are listed under the Health and Safety legislation (e.g. asbestos, LSA scale) may pose potential health hazards to the deconstruction crews and will require controlled removal and disposal by approved licensed and trained contractors.

Table 4.5, and "listed materials" referred to above, are discussed in more detail in the next section.

Paint

Lead and zinc is contained in some paints and other corrosion protection coatings, that is used, in particular, in the splash and atmospheric zones. It would clearly not be practical to remove this source. The protection of the jackets against corrosion, also it adds some lifetime to the structures used for artificial reef components.

NORM/LSA

The LSA scale (Low Specific Activity Scale) and NORM (Naturally Occurring Radioactive Materials) found on oil producing installations is a combination of barium and strontium sulphates formed by the mixing of injection water and formation water. This scale contains the radioactive elements which occur naturally in the producing formations, as these precipitate as complex inorganic sulphates and carbonates under the same conditions as the barium and strontium sulphates.

The scale is generally hard and very difficult to treat with scale dissolves and impossible to remove completely although some reduction in radioactivity can be achieved. As a result, mechanical clean-out is the only practical method of removal for both scale and sludges containing some radioactive scale material. Solid scale will have to be removed from tubing, vessels, piping etc. and transported in approved containers to approved disposal sites. Alternatively the piping sections can be removed, correctly sealed for transportation, and taken onshore for de-scaling and either returned to service or scrapped.

Sludges are handled separately from hard scale as the level of radioactivity is generally lower and the sludge will likely contain some residual oil. Sludges will be pumped via a vacuum pump into drum containers which are transported to shore for disposal.

Both equipment and wastes containing LSA scale could be disposed of down a disused well during plugging and abandonment. During process decommissioning would be the best time to deal with the problem of removing LSA contamination whether from scale or sludge. The cost of removing LSA scale contamination on a particular platform during decommissioning is impossible to accurately predict without knowing the exact nature and extent of contamination at the time of decommissioning., Estimates recently conducted however by REL (REL, 1995) calculated the onshore decontamination of flow-lines and vessels as up to NOK 2,000,000. This does not include the removal and disposal of contaminated sludge.

4.10.4 Waste management and risk considerations

4.10.4.1 Waste management

The waste management policy for dismantling an offshore structure will be based upon the Waste Management Hierarchy which has the principle aim of promoting "sustainable" waste management solutions to minimise quantities going to landfill.

During the offshore structure dismantling activities the possibility of encountering quantities of hazardous materials necessitate the presence of a fully established waste disposal trail. In Table 4.5 for the register of material, recommended practice for each category of different material are suggested together with comments.

All hazardous wastes will only be handled by personnel wearing appropriate protective clothing and in accordance with hazard data sheet instructions. All hazardous materials from the jackets, if required to be stored onshore will be labelled, logged and stored in designated areas. Labelling should follow standard guidelines set for these materials. Typical disposal routes for material from a dismantled platform are presented in Figure 4.6.

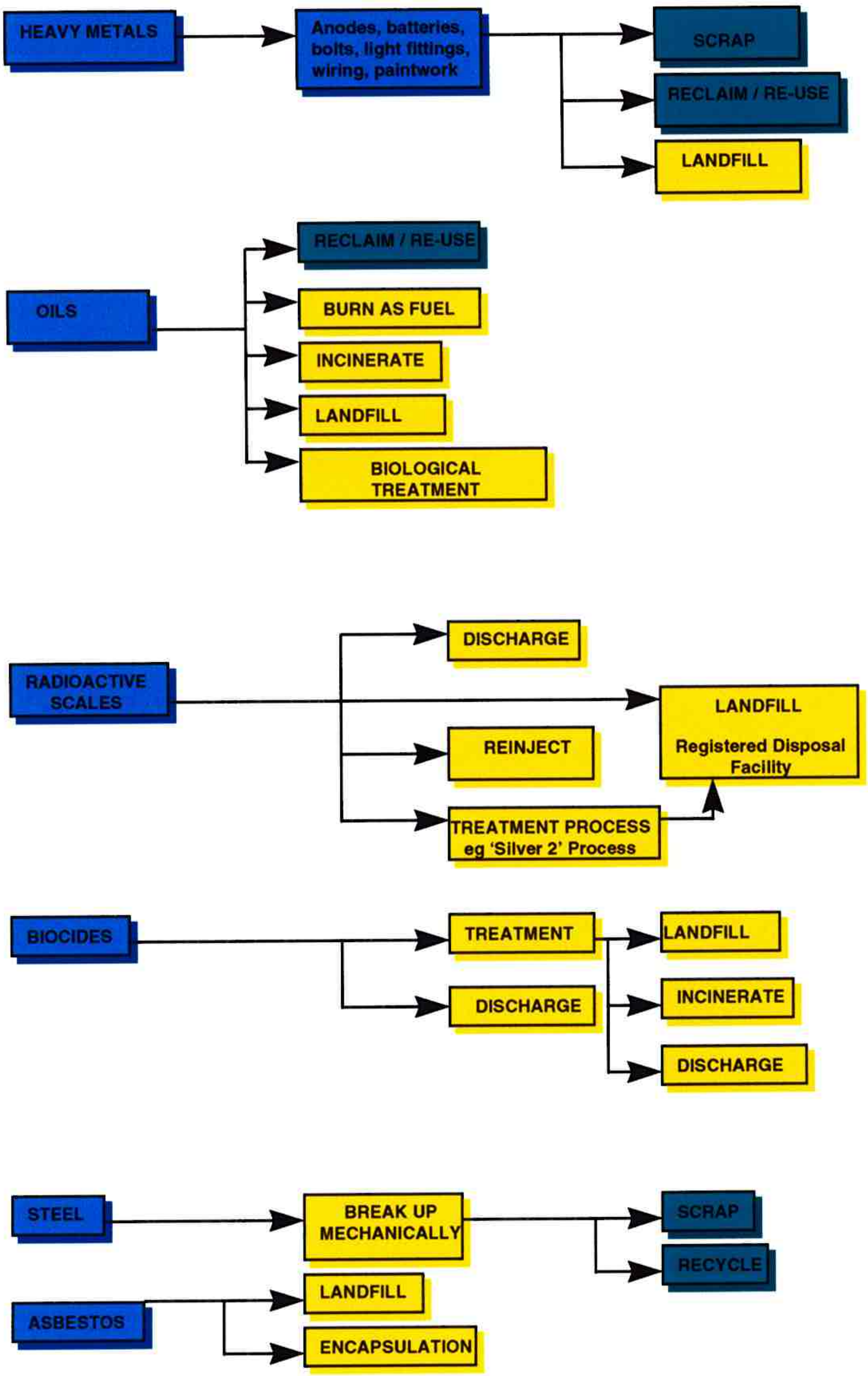

Figure 4.6: *Typical Disposal Routes(Source: Dames & Moore 1996)*

It is assumed that, where possible, liquid wastes generated during decommissioning and the preparation stages of abandonment will either be re-injected into an abandonment well, sent on-shore, or discharged on location, under licence.

Solid materials and other wastes removed during decommissioning, preparation for removal and deconstruction will be returned ashore for disposal at authorised sites. The disposal option selected will depend on the composition of the material in generic terms, the options include:

- Reuse or resale
- Recycle
- Landfill
- Incineration
- Specialist Disposal

In case of chemicals, biocides and oil contaminated materials a chemical analysis will need to be conducted to determine the chemical composition and/or level of contamination before disposal at a suitable licensed site.

4.10.4.2 Risk considerations

A Risk and Safety Assessment will need to be performed on all onshore and offshore handling activities. The results of this assessment will ultimately be used in the review and update of all existing working procedures to ensure a safe operation. Particular areas of interest are:

- off-loading and heavy lift procedures;
- secondary deconstruction and separation of materials;
- on site handling of materials;
- handling of hazardous waste.

Fundamental to any risk assessment is the identification of sources of contamination, potentially exposed receptors (targets) and pathways through which the latter can become exposed to the former. The risk assessment provided in this section are limited, but enough to give reasonable recommendations in terms of waste management for the material removed from the jackets.

It is important to recognise that, although metals and radionuclides are likely to be incorporated into sediments where they may enter the food chain via benthic invertebrates. It is possible that, before incorporation into bottom sediments, and following resuspension, there may be some potential for these substances to enter the food chain, however, the slow rates of dissolution and the diluting and dispersing effects of the marine environment should be considered.

The potential risks associated with hydrocarbons are likely to be in-significant based on:

- the high potential for degradation;
- dispersal (although the potential for accumulation in the marine micro-layer should be addressed using a quantitative approach;
- absorption into the sediments;
- relatively small amounts involved.

4.10.4.3 Risk consideration recommendations

The following recommendations in regards to waste management were proposed from the findings of the preliminary risk assessment:

- persistent synthetic substances should be removed where possible;
- production chemicals should be taken onshore for disposal;
- pipe-work should be cleaned as thoroughly as possible to remove residual sediments (containing heavy metals) and hydrocarbons as far as practicable;
- components/equipment containing radionuclides should be removed.

4.11 Further work

Prior to the establishment of one or several artificial reefs at the Ekofisk field, some further work will be required within the fields of impact assessment and waste management.

4.11.1 Scenario specific impact assessment

In this report, environmental and socio-economic impacts have been assessed in general terms for a range of likely implementation scenarios. The aim of the study was to identify areas of risk at an early stage and assist in the choice of a suitable reef creation scenario (if any).

Once a scenario has been chosen, logistic aspects such as structures to be used and time-frame for implementation, will need to be accurately planned based on the plans presented in report 3 *Configuration*. At this stage, decisions will need to be based mainly on economic and engineering requirements (a general environmental assessment having already been conducted).

Knowing the detailed plan and some of the likely practical deviations from the plan that may occur, more accurate environmental and socio-economic impact assessments can be conducted. These should lead to a scenario-specific EIS, that can be used for planning, feasibility assessment, discussion, communications and impact reduction purposes. This would be presented to the authorities.

4.11.2 Actual impacts occurring

Ekofisk platforms will probably be the first large petroleum structures to be used as artificial reefs if is so decided. Their conversion to this use is therefore an opportunity to study several aspects of reef creation. Data gained may be vital for both assessing the viability of future similar projects and for improving the efficiency with which they operate according to their desired function (i.e. habitat protection of fishing enhancement).

Similarly, in the context of EIAs, a study of the actual impacts that did occur during the implementation, start-up and operational phases, would provide data not only ensuring that negative impacts were minimised, but would provide experience for future projects. Additionally, monitoring of the expected positive impacts, such as protected biomass increases, would assist in the management of the reef.

A monitoring plan, incorporating an assessment of the actual positive and negative environmental impacts that did occur as a result of reef creation, is therefore proposed in report 6 *Monitoring Programme*.

4.11.3 Waste management plan

Once the actual reef creation scenario(s), if any, has been decided upon and a more detailed technical plan for implementation has been prepared (see 4.11.1), there will be a need to plan in detail for the removal of the materials that cannot be left offshore as part of the artificial reef. This has been discussed in general terms in section 4.10.

'Waste', or perhaps more correctly 'non-reef material' will need to be identified and quantified. A plan for its removal from the remaining reef structure will need to be proposed. This will include aspects such as: efficient logistics; environmental and health & safety risk assessment; maximisation of reuse; capacity of, and arrangements for, treatment or final disposal facilities.

4.12 References

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Appendix

4.1 IMO Guidelines and standards for the removal of offshore installations

RESOLUTION A.672(16)

Adopted on 19 October 1989
Agenda item 10

GUIDELINES AND STANDARDS FOR THE REMOVAL OF OFFSHORE INSTALLATIONS AND STRUCTURES ON THE CONTINENTAL SHELF AND IN THE EXCLUSIVE ECONOMIC ZONE

THE ASSEMBLY,

RECALLING Article 15(j) of the Convention on the International Maritime Organization concerning the functions of the Assembly in relation to regulations and guidelines concerning maritime safety and the prevention and control of marine pollution,

BEARING IN MIND article 60 of the United Nations Convention on the Law of the Sea, 1982, which prescribes that 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 organization, and that such removal shall also have due regard to fishing, protection of the marine environment and the rights and duties of other States,

BEARING IN MIND ALSO that the International Maritime Organization is the competent Organization to deal with this subject,

HAVING CONSIDERED the draft guidelines and standards approved by the Maritime Safety Committee at its fifty-seventh session which were developed in co-operation with the Marine Environment Protection Committee,

1. ADOPTS the Guidelines and Standards for the Removal of Offshore Installations and Structures on the Continental Shelf and in the Exclusive Economic Zone set out in the Annex to the present resolution;

2. RECOMMENDS that Member Governments take into account the aforesaid Guidelines and Standards when making decisions regarding the removal of abandoned or disused installations or structures.

ANNEX

GUIDELINES AND STANDARDS FOR THE REMOVAL OF OFFSHORE INSTALLATIONS AND STRUCTURES ON THE CONTINENTAL SHELF AND IN THE EXCLUSIVE ECONOMIC ZONE

1 GENERAL REMOVAL REQUIREMENT

1.1 Abandoned or disused offshore installations or structures on any continental shelf or in any exclusive economic zone are required to be removed, except where non-removal or partial removal is consistent with the following guidelines and standards.

1.2 The coastal State having jurisdiction over the installation or structure should ensure that it is removed in whole or in part in conformity with these guidelines and standards once it is no longer serving the primary purpose for which it was originally designed and installed, or serving a subsequent new use, or where no other reasonable justification cited in these guidelines and standards exists for allowing the installation or structure or parts thereof to remain on the sea-bed. Such removal should be performed as soon as reasonably practicable after abandonment or permanent disuse of such installation or structure.

1.3 Notification of such non-removal or partial removal should be forwarded to the Organization.

1.4 Nothing in these guidelines and standards is intended to preclude a coastal State from imposing more stringent removal requirements for existing or future installations or structures on its continental shelf or in its exclusive economic zone.

2 GUIDELINES

2.1 The decision to allow an offshore installation, structure, or parts thereof, to remain on the sea-bed should be based, in particular, on a case-by-case evaluation, by the coastal State with jurisdiction over the installation or structure, of the following matters:

.1 any potential effect on the safety of surface or subsurface navigation, or of other uses of the sea;

.2 the rate of deterioration of the material and its present and possible future effect on the marine environment;

.3 the potential effect on the marine environment, including living resources;

.4 the risk that the material will shift from its position at some future time;

.5 the costs, technical feasibility, and risks of injury to personnel associated with removal of the installation or structure; and

.6 the determination of a new use or other reasonable justification for allowing the installation or structure or parts thereof to remain on the sea-bed.

2.2 The determination of any potential effect on safety of surface or subsurface navigation or of other uses of the sea should be based on: the number, type and draught of vessels expected to transit the area in the foreseeable future; the cargoes being carried in the area; the tide, current, general hydrographic conditions and potentially extreme climatic conditions; the proximity of designated or customary sea lanes and port access routes; the aids to navigation in the vicinity; the location of commercial fishing areas; the width of the available navigable fairway; and whether the area is an approach to or in straits used for international navigation or routes used for international navigation through archipelagic waters.

2.3 The determination of any potential effect on the marine environment should be based upon scientific evidence taking into account: the effect on water quality; geological and hydrographic characteristics; the presence of endangered or threatened species; existing habitat types; local fishery resources; and the potential for pollution or contamination of the site by residual products from, or deterioration of, the offshore installation or structure.

2.4 The process for allowing an offshore installation or structure, or parts thereof, to remain on the sea-bed should also include the following actions by the coastal State with jurisdiction over the installation or structure: specific official authorization identifying the conditions under which an installation or structure, or parts thereof, will be allowed to remain on the sea-bed; the drawing up of a specific plan, adopted by the coastal State, to monitor the accumulation and deterioration of material left on the sea-bed to ensure there is no subsequent adverse impact on navigation, other uses of the sea or the marine environment; advance notice to mariners as to the specific position, dimensions, surveyed depth and markings of any installations or structures not entirely removed from the sea-bed; and advance notice to appropriate hydrographic services to allow for timely revision of nautical charts.

3 STANDARDS

The following standards should be taken into account when a decision is made regarding the removal of an offshore installation or structure.

3.1 All abandoned or disused installations or structures standing in less than 75 m of water and weighing less than 4,000 tonnes in air, excluding the deck and superstructure, should be entirely removed.

3.2 All abandoned or disused installations or structures emplaced on the sea-bed on or after 1 January 1998, standing in less than 100 m of water and weighing less than 4,000 tonnes in air, excluding the deck and superstructure, should be entirely removed.

3.3 Removal should be performed in such a way as to cause no significant adverse effects upon navigation or the marine environment. Installations should continue to be marked in accordance with IALA recommendations prior to the completion of any partial or complete removal that may be required. Details of the position and dimensions of any installations remaining after the removal operations should be promptly passed to the relevant national authorities and to one of the world charting hydrographic authorities. The means of removal or partial removal should not cause a significant adverse effect on living resources of the marine environment, especially threatened and endangered species.

3.4 The coastal State may determine that the installation or structure may be left wholly or partially in place where:

.1 an existing installation or structure, including one referred to in paragraphs 3.1 or 3.2, or a part thereof, will serve a new use if permitted to remain wholly or partially in place on the sea-bed (such as enhancement of a living resource); or

.2 an existing installation or structure, other than one referred to in paragraphs 3.1 and 3.2, or part thereof, can be left there without causing unjustifiable interference with other uses of the sea.

3.5 Notwithstanding the requirements of paragraphs 3.1 and 3.2, where entire removal is not technically feasible or would involve extreme cost, or an unacceptable risk to personnel or the marine environment, the coastal State may determine that it need not be entirely removed.

3.6 Any abandoned or disused installation or structure, or part thereof, which projects above the surface of the sea should be adequately maintained to prevent structural failure. In cases of partial removal referred to in paragraphs 3.4.2 or 3.5, an unobstructed water column sufficient to ensure safety of navigation, but not less than 55 m, should be provided above any partially removed installation or structure which does not project above the surface of the sea.

3.7 Installations or structures which no longer serve the primary purpose for which they were originally designed or installed and are located in approaches to or in straits used for international navigation or routes used for international navigation through archipelagic waters, in customary deep-draught sea lanes, or in, or immediately adjacent to, routeing systems which have been adopted by the Organization should be entirely removed and should not be subject to any exceptions.

3.8 The coastal State should ensure that the position, surveyed depth and dimensions of material from any installation or structure which has not been entirely removed from the sea-bed are indicated on nautical charts and that any remains are, where necessary, properly marked with aids to navigation.The coastal State should also ensure that advance notice of at least 120 days is issued to advise mariners and appropriate hydrographic services of the change in the status of the installation or structure.

3.9 Prior to giving consent to the partial removal of any installation or structure, the coastal State should satisfy itself that any remaining materials will remain on location on the sea-bed and not move under the influence of waves, tides, currents, storms or other foreseeable natural causes so as to cause a hazard to navigation.

3.10 The coastal State should identify the party responsible* for maintaining the aids to navigation, if they are deemed necessary to mark the position of any obstruction to navigation, and for monitoring the condition of remaining material. The coastal State should also ensure that the responsible party* conducts periodic monitoring, as necessary, to ensure continued compliance with these guidelines and standards.

3.11 The coastal State should ensure that legal title to installations and structures which have not been entirely removed from the sea-bed is unambiguous and that responsibility for maintenance and the financial ability to assume liability for future damages are clearly established.

3.12 Where living resources can be enhanced by the placement on the sea-bed of material from removed installations or structures (e.g. to create an artificial reef), such material should be located well away from customary traffic lanes, taking into account these guidelines and standards and other relevant standards for the maintenance of maritime safety.

3.13 On or after 1 January 1998, no installation or structure should be placed on any continental shelf or in any exclusive economic zone unless the design and construction of the installation or structure is such that entire removal upon abandonment or permanent disuse would be feasible.

3.14 Unless otherwise stated, these standards should be applied to existing as well as future installations or structures.

* The phrase "party responsible" refers to any juridical or physical person identified by the coastal State for a purpose mentioned in the above paragraph 3.10.