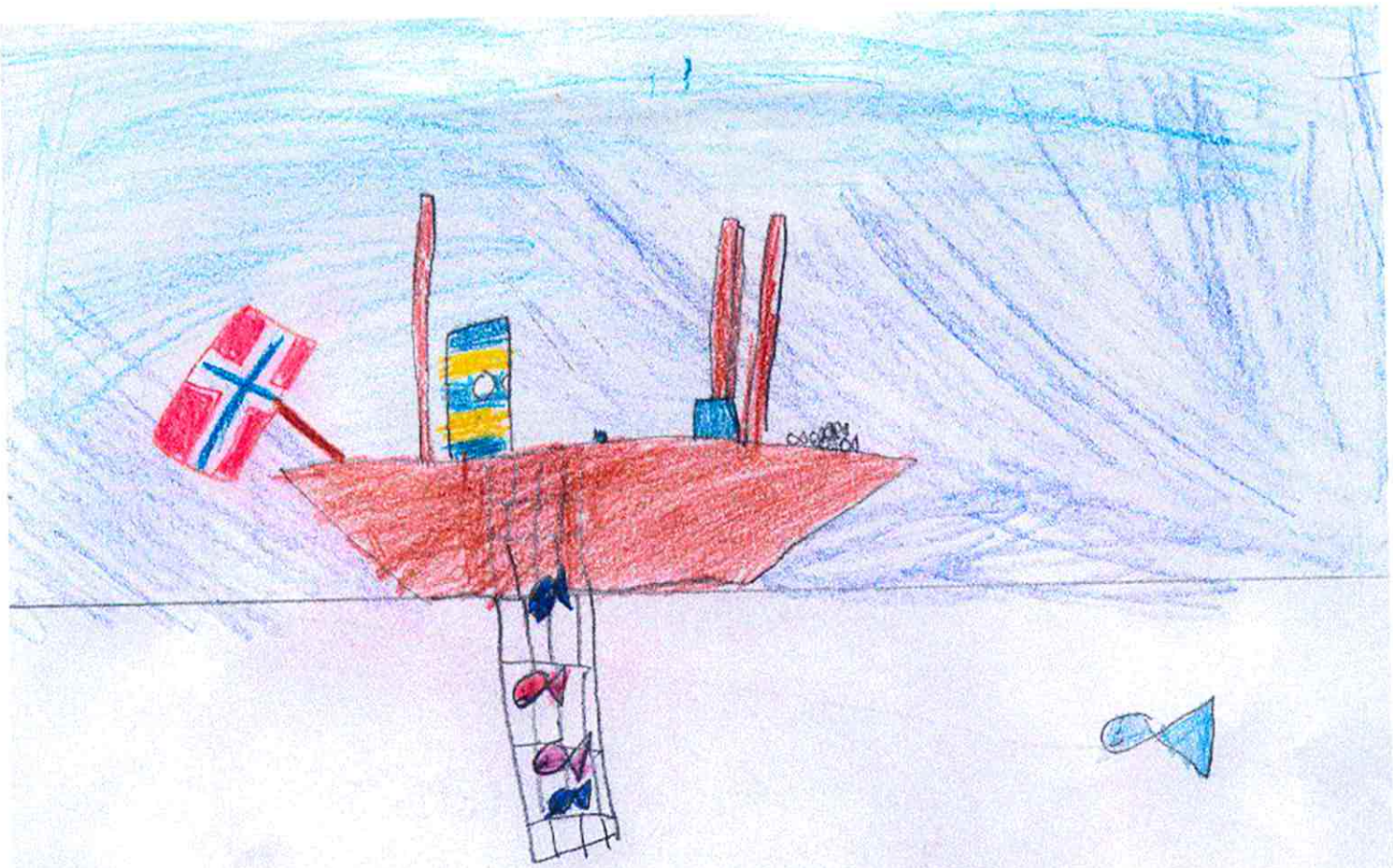
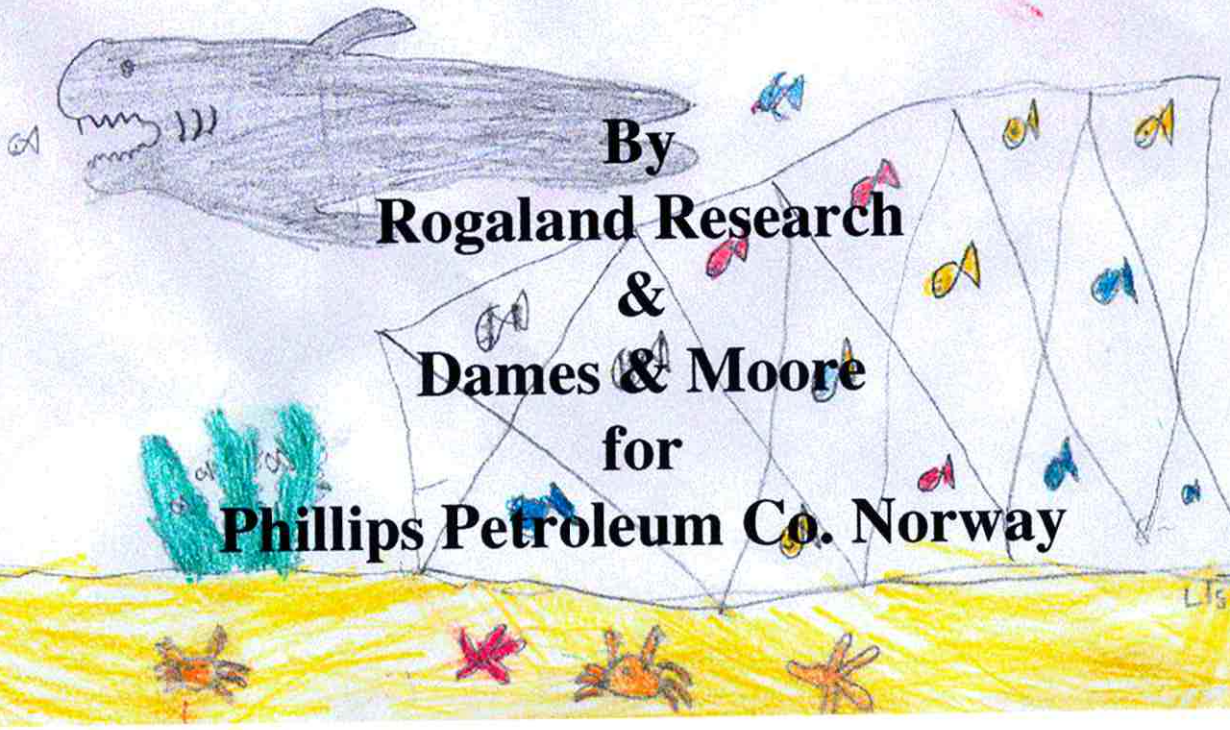


EKOREEF

Summary report



By

Rogaland Research

&

Dames & Moore

for

Phillips Petroleum Co. Norway

EKOREEF - Report 1: Summary

Report RF-98/022 - D&M 37363.001

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Scope:

The project has delivered a comprehensive and integrated plan and feasibility study for the design, management and assessment of a complex artificial reef built on the Ekofisk field, including around the Ekofisk Tank 2/4T, using suitably prepared and relocated redundant structures from the Greater Ekofisk field.

Key-words:

Ekofisk, artificial reef, environment, rigs to reefs, fisheries management, decommissioning, Ekoreef, offshore platforms, GIS.

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2 DAMES & MOORE
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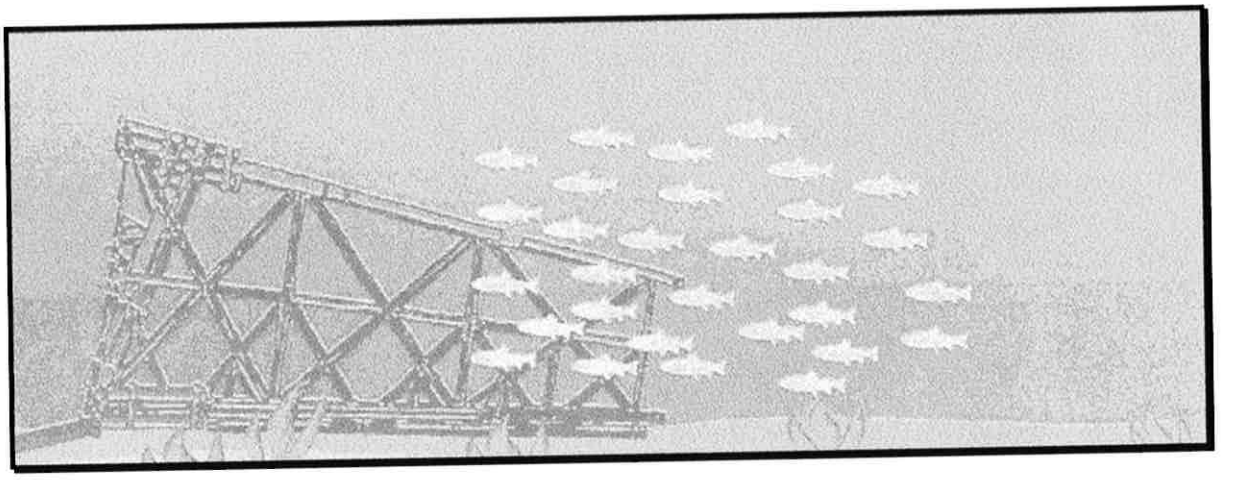
CONTENTS

1 EKOREEF SUMMARY REPORT

1.1 Summary

- The conversion of decommissioned jacket structures into complex artificial reefs is a viable and serious concept.
- There are structures and locations within the Ekofisk region that would be suitable for such reefs.
- Negative and positive impacts from these reefs would be expected.
- On balance, evidence and conjecture suggests that habitat and stock protection reefs may be more beneficial than fishing reefs.



1.2 Introduction

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 summarises the findings of the projects 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.

As requested, the report has been written in an easily accessible style with the minimum of technical jargon. The style of the report was aimed to attract interest and provoke a reasoned, balanced debate on the subject. Though large in size, due to the many aspects in this multidisciplinary study that are considered, it has been broken into logical sections. The main report serves as a verifiable reference behind the conclusions and recommendations presented in this summary.

The structure of the programme is summarised in Figure 1.1.

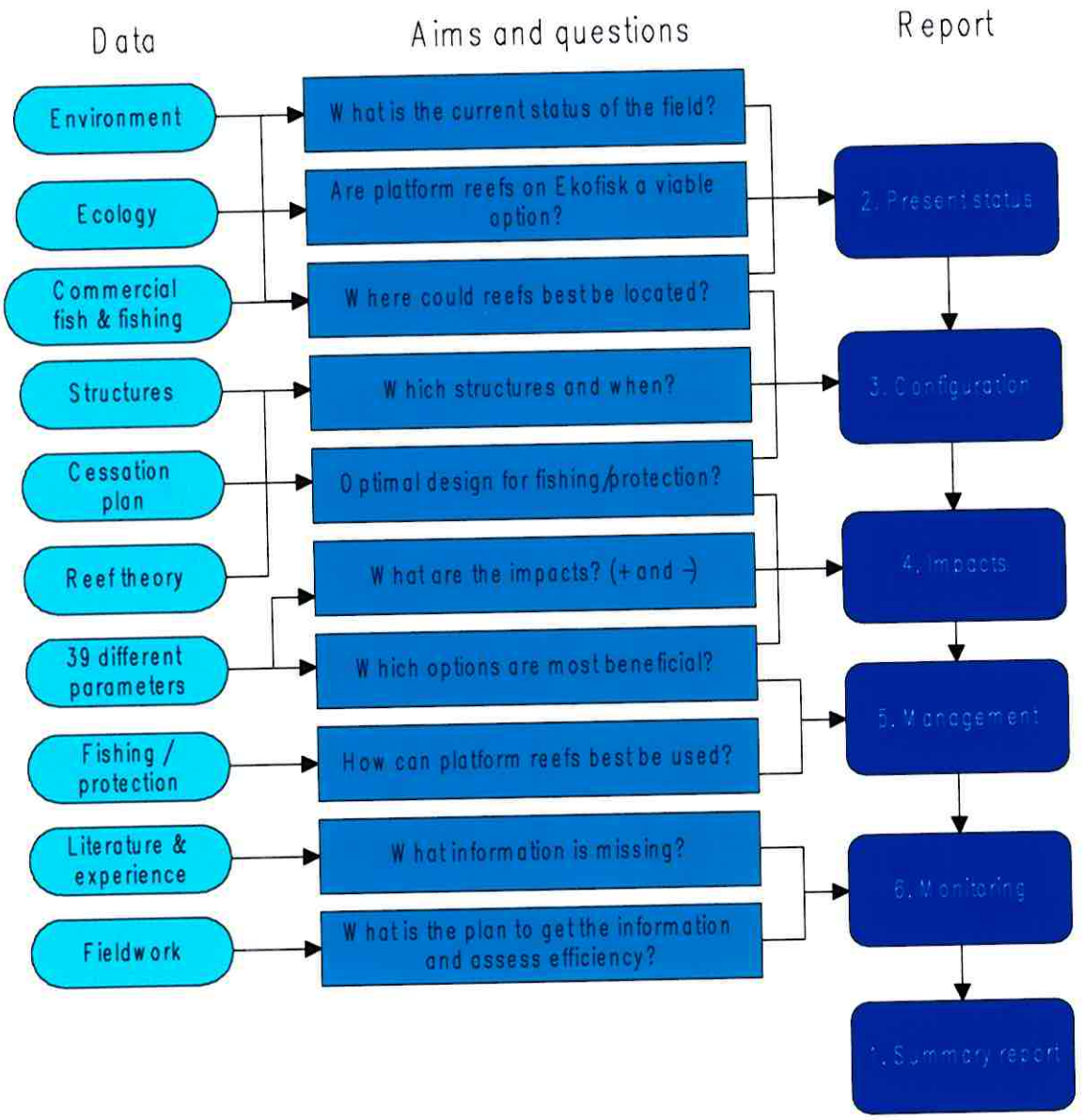


***Figure 1.1**: Ekoreef programme organisation.*

1.3 Present status and suitability

Adequate planning and locating are two of the main factors, in addition to management, that determine the success or otherwise of an artificial reef. This study (Report 2: *Present status*) reviewed a range of site selection criteria, general indicators of the status of the field, and the structures that are presently on the field, including those that will be available as part of the cessation programme and those that will remain.

The four main aims of this study were:

1. to indicate the general status of the Ekofisk field and associated fields, with respect to the implementation of platform reefs;
2. to identify locations that would and would not be suitable for the construction of complex platform reefs;
3. to describe and map the status of the field as a basis for the design phase;
4. to evaluate if there appears to be potential, based on the field status data, for the implementation of one or several reefs.

The 25 main structures at the Ekofisk and associated fields are shown in Figure 1.2. The distance between the structures is not to scale, in order to show all the jackets. In addition to the main structures, it can been seen that there are many local (within the field) and export (to outside the field) pipelines. Not all of the 25 local pipelines are shown in this Figure. Such structures complicate the positioning of a reef.

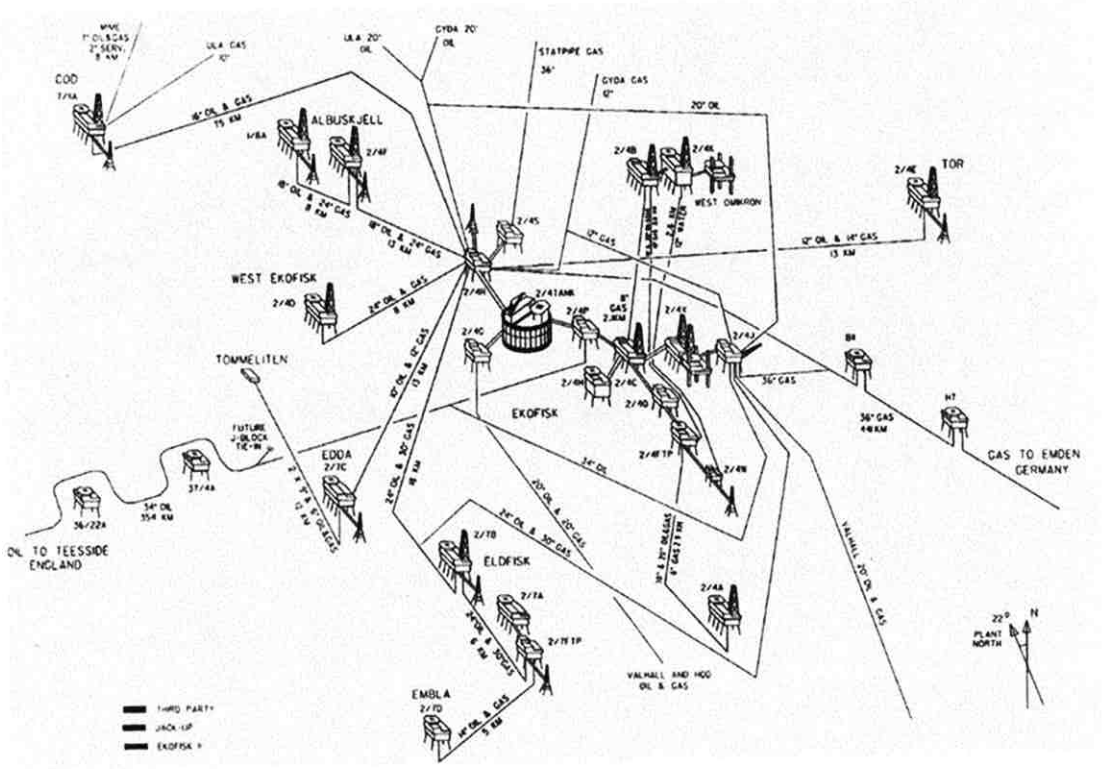


Figure 1:2: *Pictorial representation of the structures on the Ekofisk and associated fields.*

The results of this study indicate that there are locations in the Ekofisk area where environmental conditions and water quality are suitable for reef creation. The sediments to the south of the Ekofisk Centre complex and close to some of the main drilling platforms are contaminated. This is indicated by the presence of pollutants and the alteration of the bottom living animal communities. Figure 1.3 shows to Geographical Information system (GIS) maps constructed as part of this study.

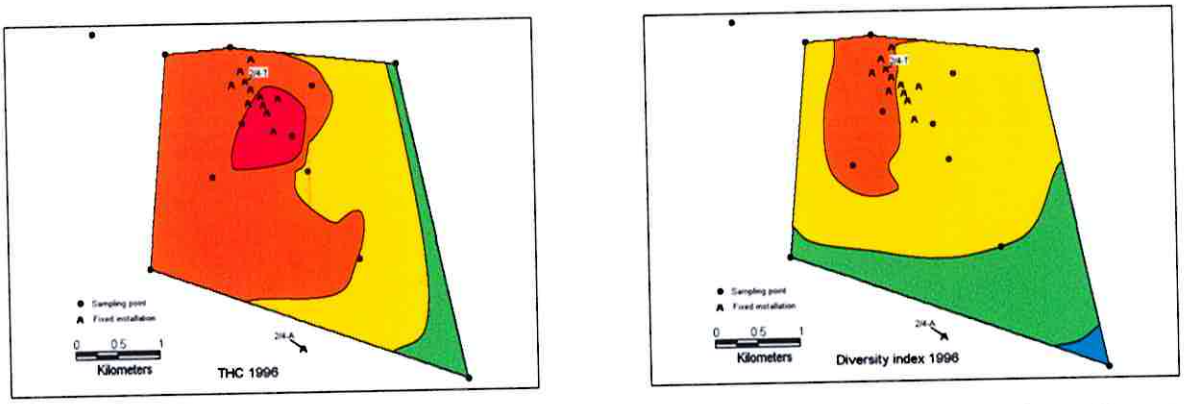


***Figure 1.3**: Total hydrocarbon concentrations and distribution of organisms in the sediments around the Ekofisk Tank (for key see Appendix 2.1).*

Whilst such areas appear to be improving, thus reducing the likelihood of significant quantities of these pollutants being accumulated in the major commercial fish species inhabiting a reef, it is considered good practice to avoid such sites: the Precautionary Principle. Damage to the complex pipeline networks around the producing platforms, and the risk of disrupting cuttings piles at the platforms where drilling has occurred, indicates that areas of currently greatest industrial activity towards the southern end of the Centre complex, should be avoided. Some transport of jackets will then be required.

From a fisheries viewpoint, there is no major reason to suggest that the Ekofisk area would be unsuitable as a reef site. None of the fisheries for the different species caught in the area are likely to be harmed, and indeed benefits are expected. Due to the small size of the fish populations in the central North Sea region (Figure 1.4), relative to the North Sea as a whole, fishing activity is not intense in the area, so fishing is unlikely to be greatly hampered.

A survey of fish around the Ekofisk platforms was conducted using existing structure inspection ROV (Remote Operated Vehicle) videos. The following conclusions were made:

- pelagic fish were generally not attracted to the Ekofisk structures;
- the survey was conducted at a time when few pelagic fish would be expected to be present;
- large numbers of demersal fish, mainly cod and saithe, were observed at the majority of structures;
- high profile reefs would be expected to be of little extra benefit than low profile reefs with an extended base area;
- larger complexes may have attracted more fish than smaller individual units.

The petroleum industry in the area has presented the opportunity to establish artificial reefs by supplying large structures of a design that approximates the most optimum currently available. With proper planning, these structures could be used, at no cost to the fishing industry, as a management tool.

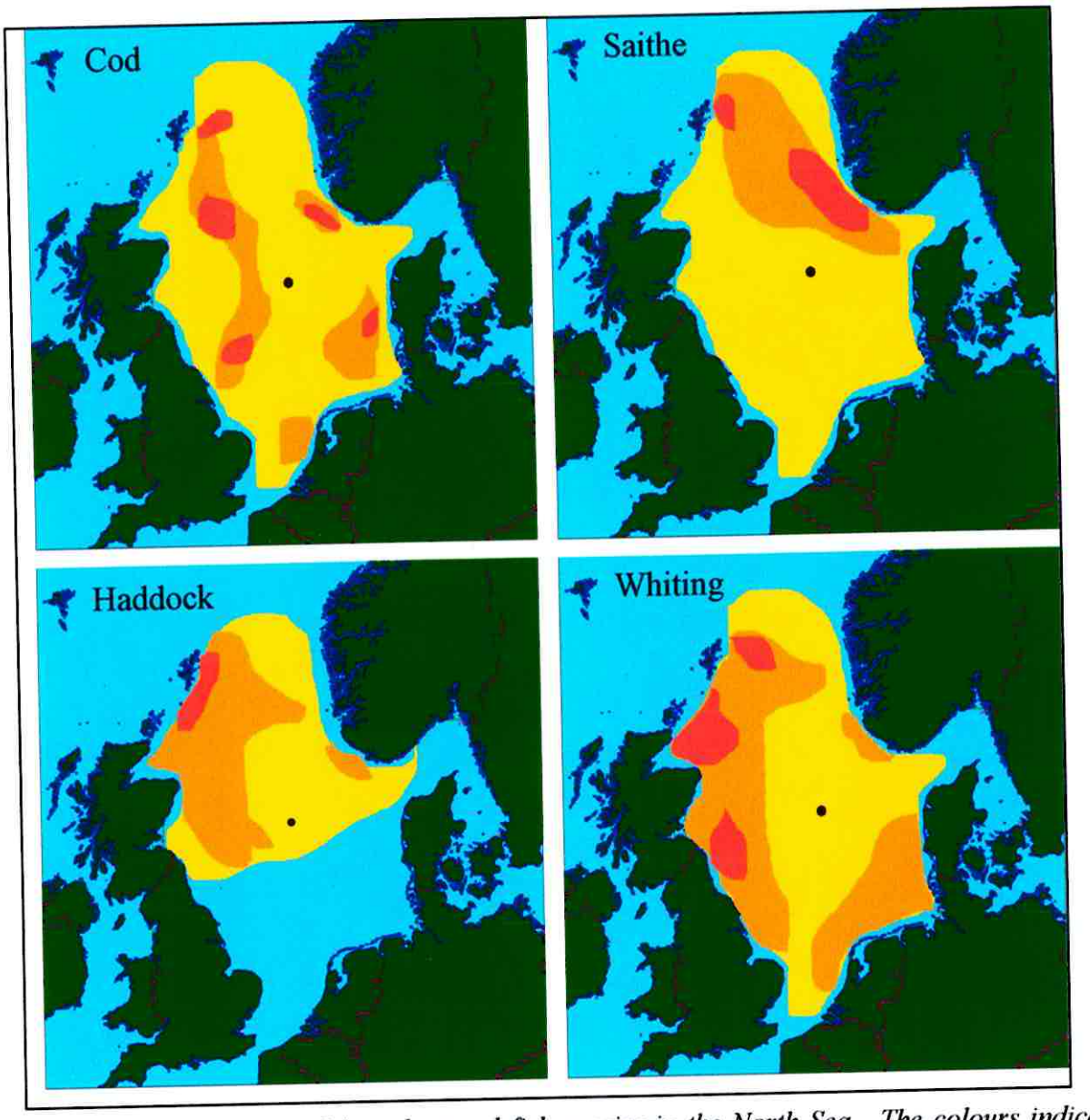


Figure 1.4: *Distribution of four demersal fish species in the North Sea. The colours indicate the relative concentration of fish in the respective areas. Yellow area = low concentrations, Orange area = medium concentration, Red area = high concentration (main area).*

Using a wide range of determining facility and environment-based criteria, there appear to be four suitable sites for the creation of complex artificial reefs: around the Ekofisk Tank, Albuskjell 1/6A, Eldfisk 2/7B and Tor 2/4E.

There is therefore great potential for the establishment of platform reefs in the Ekofisk area, providing that the areas of greatest industrial activity and to the south of the Centre complex are avoided.

1.4 Configuration

The overall aim of this study (Report 3: *Configuration*) was to propose the configurations of several reef options at the Greater Ekofisk field. The four main aims of this study were to:

- define the locations of potential artificial reefs;
- identify and rank the usefulness of structures to be used as artificial reef components;
- design artificial reefs;
- present alternative scenarios for their creation.

To reduce the complexity of this multi-component task, several assumptions and limitations were made:

- the Ekofisk Tank will serve as an artificial reef site, from the time of its abandonment;
- the economic lifetimes of the platforms are divided in two groups, those planned to be decommissioned in 1998-2005, and those decommissioned after 2005;
- an economic evaluation of the reef configurations was not within the remit of this study;
- only jacket-structures are used as reef components, not topside modules or MSVs (decking).

This study was divided into four main parts:

1. identification of suitable locations for the artificial reefs;
2. identification of potential reef component structures;
3. design of the artificial reefs;
4. scenarios for establishing one or several Ekoreefs.

Each of these 4 parts were then divided into: introduction, identification, criteria, and evaluation.

Reef locations

The following parameters were used to determine potential reef locations:

- oceanographic parameters;
- prevalence of fish;
- drill cuttings disposal options;
- location of pipelines;
- contamination concentration and distribution;
- platform location.

The Ekofisk Tank, Albuskjell 1/6 A, and Eldfisk 2/B were chosen as potential reef sites. *In situ* toppling was discussed as a potential option.

Reef structures

Existing facilities and their economic lifetime were identified, together with considerations such as: interaction with operating platforms and risk of decommissioning activity; stability of structures; transport of jackets vs. toppling in place. Criteria for structures were: volume and

structural complexity of jacket; toppling in-place, or transport of jacket; and economic lifetime of the jackets. The jackets were evaluated and ranked, focusing on the usefulness of each structure at either the Ekofisk Tank, Albuskjell 1/6 A or Eldfisk 2/7-B sites.

Design of artificial reefs

Reefs were designed in a straight line to assist commercial fishing, and in a block or circular formation for habitat protection. Reef design criteria differed from criteria used to determine suitable locations and structures. Orientation, i.e. bearing; juxta-position of jackets within a reef; number of jackets at the reef; and distance between jackets in the reef were used as design criteria.

Ekoreef scenarios

The following six main alternative scenarios were defined:

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 each of the first 5 Alternatives, both a habitat protection (p) and an enhanced fishing design (f) are presented. A total of 11 alternatives were then proposed

The GIS-based presentation of each scenario is shown in Appendix 1.1. The GIS database contains the following information:

- production fields around the platforms;
- location of pipelines, both export and production pipelines;
- total hydrocarbon (THC) contamination concentration and distribution in the sediments;
- location of each platform structure placed in a reef unit;
- volume of each structure, indicated by use of colour codes;
- use for habitat protection or enhanced fishing.

Conclusions and recommendations

The Ekofisk Tank is suggested as a potential reef site, assuming it is to be abandoned. It is sited in close proximity to several platforms that could be toppled in-place. It is expected that the current unsuitable sediment contamination levels in the area may improve with time because of cleaner production techniques and reduced oil industry activity.

The Albuskjell 1/6-A and Eldfisk 2/7-B are also suggested as artificial reef sites, because of the absence of pipelines, and low contamination levels. There are several platforms in the vicinity.

In situ toppling is suggested as a potential alternative, primarily because the cost of reef implementation would be relatively low. The resulting reef configuration would be more suitable for habitat protection than for enhanced fishing. Reef design flexibility and localisation is though limited.

Though a cost analysis was not within the remit of this study, from a solely financial aspect, the most favourable Alternative appears to be 6, i.e. *in-situ* toppling. Alternative 1, creating reefs as they become available until all of the platforms are decommissioned, also appears an economically favourable scenario.

1.5 Impacts

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 part of the project (Report 4: *Impacts and waste management*) aimed, 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;
- 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 were identified. These were divided into the seven categories of impacts shown in Figures 1.5 - 1.7. The likely severity of these impacts in general, and the

potential for their reduction (negative impacts), or maximisation (positive impacts) was estimated. Techniques to accomplish this were summarised.

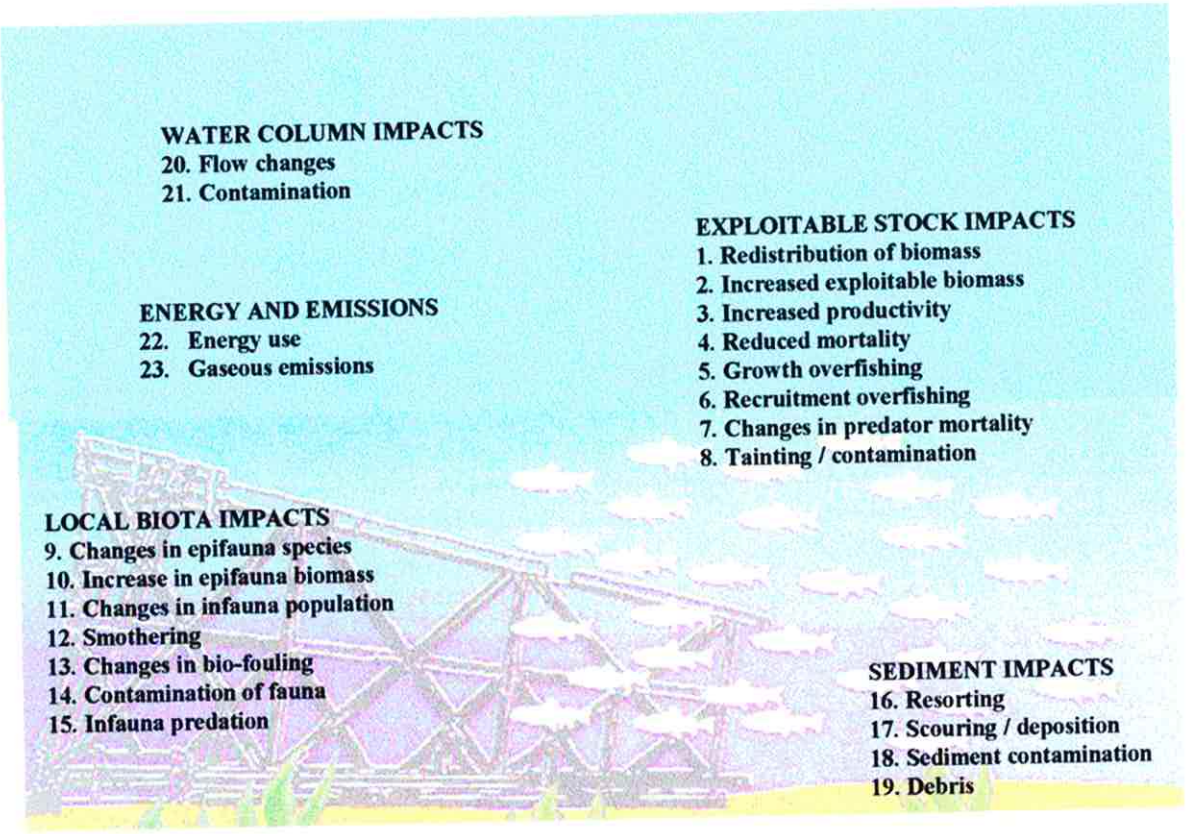


***Figure 1.5**: Summary of potential environmental impacts*

***Figure 1.6**: Summary of possible socio-economic impacts*

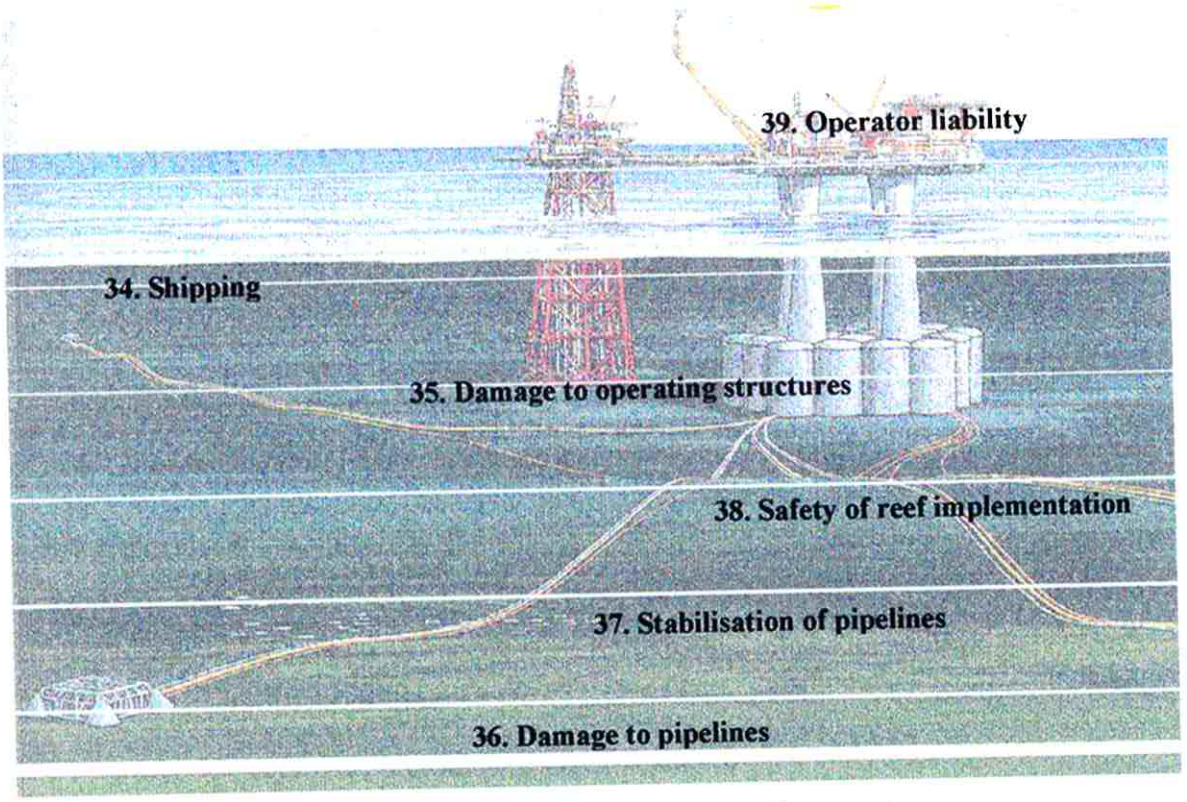


***Figure 1.7**: Summary of possible miscellaneous impacts*

Semi-quantitative impact severity scores for each defined possible impact were assigned to each of the 11 reef creation alternatives. These were totalled for each alternative, which were then ranked according to various defined criteria (Appendix 1.2).

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 it had the least energy usage and hence least emissions to the atmosphere. Though outside the remit of this study, it was nevertheless considered the safest option and the cheapest to implement, 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 was presented. The main sources of these materials, their principal components, recommended handling practice and relevant legislation were detailed. A waste management policy based on the Waste Management Hierarchy was proposed, i.e.:

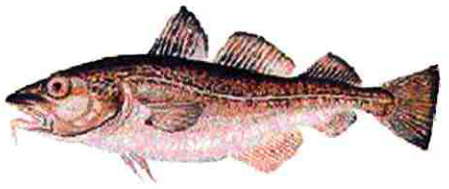
1. reduction;
2. reuse/resale;
3. recovery/recycling;
4. disposal at landfill or incineration.

The risks associated with the handling of these wastes were 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.

1.6 Management

This Ekoreef management study (Report 5: *Management plan*) had three main objectives:

1. to address management issues of use, ownership, efficiency, environmental protection and fishing practice;
2. in particular, to analyse the uses to which the reef may be put and how this may best be achieved;
3. to develop management plans for the first 10 years after establishment.



Several high value commercial fish are known to occur in the Ekofisk area, though the region does not contain high numbers of these fish. Their demersal habit indicates that fishing techniques, such as bottom trawls, that can access these fish, will be of most use. The large number of eggs produced by each female cod (3 - 7 million), and hence enormous mortality rate during early life stages, indicates that a protection reef that can assist even of small proportion of these fish to survive, has much potential.

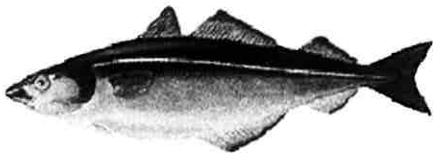
A platform reef can have many potential benefits, though not all benefits can occur at the same time on the same reef. Benefits will be dependant on: the use to which the reef is put; its efficiency as an attractor or protector; the environment in which it is placed. There are three main categories of benefit, for:

- **fisheries management**, by providing a tool for the controlled exploitation, manipulation and security of commercially caught species (not just fish);
- **fishing**, by providing enhanced fishing opportunities for commercial fishermen, potentially allowing a reduction in catch effort and an increase in catch security;
- **the environment / ecosystem**, in the form of fisheries or habitat protection, potentially providing a means to increase the number of juveniles recruiting into the fishery, stabilising the spawning stock, at least locally, and maintaining an undisturbed refuge for non-commercial species, such as the animals attached to the jacket itself.

Platform reefs can then basically be used to either assist commercial fishing, or as a protection zone.

Estimates of the attractiveness of a platform reef to fish vary, though a density of 0.3 kg fish m^{-3} is commonly quoted. Using this estimate, an average 150,000 m^{-3} steel jacket on Ekofisk would be expected to hold about 45 tonnes of fish, though not all would be commercially landable. If all structures on Ekofisk were created into reefs as planned, a total of 1,050 tonnes of fish may be attracted into a small area. It is not known how quickly these would be replenished if the reef was fished out. Over-fishing of stocks in the region is considered unlikely.

If used for commercial fishing, it would be preferable to manage fishing pressure so that economic benefits were maximised and stocks were harvested sustainably. For safety purposes, even on a fishing reef, a restricted zone for certain types of gear may be required. Use of the reef for habitat protection has much to commend it. There is precedent for such closed areas, which are strongly recommended by some fisheries managers and nature conservationists. Platform reefs may be possible to incorporate into the current review of the Common Fisheries Policy.



Various ownership options are possible ranging from open, uncontrolled access, to use by a co-operative of fishermen. Petroleum operators are the least appropriate owners of a reef, fishermen themselves are the most appropriate, with a range of options between these two. The issue of liability needs to be resolved. Legislation enforcing an exclusion zone would seem to be a suitable means to solve the problem.

Ten-year management plans for fishing and for protection were presented. The **fishing plan** seeks to answer and improve the following:

- Is the reef safe?
- If not how can this be improved?
- Are the fishermen obtaining a tangible benefit from the reef?
- How can this benefit be maximised?

- Are there significant negative environmental impacts?
- Can these be minimised, and if so would this make the impacts acceptable?

The **protection plan** seeks to answer and improve the following:

- Is the reef safe?
- If not, how can this be improved?
- Is there a benefit to the environment / fishery from the reef?
- How can this benefit be maximised?
- Are there significant negative environmental /social impacts?
- Can these be minimised, and if so would this make the impacts acceptable?

An Ekoreef Management Group is proposed, comprising representatives from various organisations such as:

1. national fisheries ministries;
2. The European Union within the Common Fisheries Policy;
3. a scientific reef advisory committee;
4. the original operator;
5. a contracted commercial group;
6. a fishermen's co-operative.

The authority of the Group will depend upon the use to which the reef is put and its level of ownership and access. The Group will be responsible for ensuring that monitoring and efficiency assessments are conducted.

The reefs must be given a chance to function. Sufficient time must be allotted in order for:

- a stabile faunal community to become established on and around the reef;
- for stakeholders to develop sustainable exploitation or protection strategies;
- for the reef managers to develop and assess their plans.

Such developments take time, so an initial trial period of not less than 10 years is recommended. Should the assessments during this time prove inconclusive, then a further trial period may be necessary.

In view of the importance of this management development and assessment strategy, for the North Sea environment, fisheries, fishermen, nature conservation, petroleum industry decommissioning and international economics, it is also recommended that no reef be established without a

management and assessment framework in place prior to implementation. Conversion of offshore structures to artificial reefs (even if conducted carefully), without adequate follow-up, does no service to either the petroleum industry or stakeholders, in the long-run.

The findings of this part of the study tend to indicate that the use of Ekoreef as a protected zone is likely to have greater benefits than its use to enhance commercial fishing.

1.7 Monitoring

This part of the study provides an overview of the elements that should be performed during a monitoring programme during the first five years. The monitoring programme also includes some of the elements in the guidelines for surveillance of operating platforms from the Norwegian Pollution Control Authorities (SFT). The aims of the proposed programme of work are as follows:

1. to determine if, and for how long, a platform reef retains a fish population, and the size of that population;
2. to determine if the platform reef is having any measurable beneficial or detrimental effect on the health, growth and commercial value of the fish it retains;
3. to determine if the platform reef enhances fish reproduction and/or gain in tissue weight;
4. to determine if the platform is used by juvenile fish;
5. to determine if the platform reef is having any measurable effect on the pelagic (water column) and benthic environments in its immediate vicinity;
6. to assess if a platform reef could be fished sustainably by commercial fishermen;
7. to describe and evaluate the fouling organisms on the platform reef as a food supply for commercial species and for nature conservation value.

To achieve these objectives, an integrated programme of work is proposed, with an emphasis on commercial fish as these animals are perceived as the most significant from an exploitable resource viewpoint. The programme would involve periodic offshore surveys and sampling from a vessel. On these occasions a wide range of samples would be obtained in order to maximise the value of the ship's time. Some samples would be analysed immediately, others might be archived for possible future study. There would also be routine, longer term monitoring by remote equipment on the seabed or on the platform. A summary of a full monitoring programme is shown in Figure 1.8.

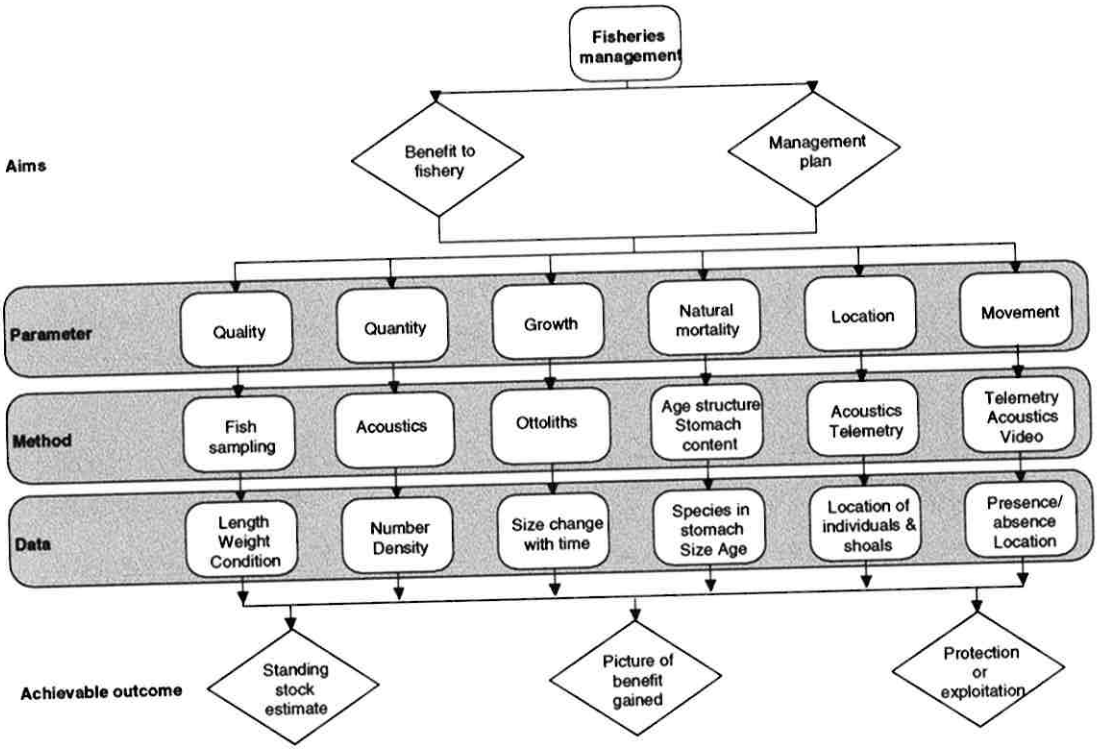


***Figure 1.8**: Summary of the fisheries work proposed and achievable outcomes.*

1.8 Main conclusions

Present status

1. There are 25 main structures at the Ekofisk and associated fields, amounting to 3.5 Mm^3 of jacket volume, and at least 25 local pipelines.
2. Environmental conditions and water quality in the Ekofisk area are suitable for reef creation.
3. Sediments to the south of the Ekofisk Centre complex and close to some of the main drilling platforms are contaminated, though improvements with time are expected.
4. The risk of contaminating fish is expected to reduce with time, but sites of high industrial activity should be avoided as a precautionary principle.
5. The central North Sea area has many of the main commercial fish, though not in great numbers.

6. As a result of this, fishing activity is low compared with coastal regions, so the fishing industry would not be greatly disturbed by the presence of platform reefs.

7. Large numbers of cod and saithe were observed around the base of many of the operational platforms at Ekofisk, though no pelagic fish were found.

8. Extensive, rather than high profile reefs may be more suitable in the Ekofisk area. This could be adequately achieved by lying the jackets with their longest side downwards, rather than by dividing up the jackets.

9. There is therefore great potential for the establishment of platform reefs in the Ekofisk area.

Configuration

10. 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.

11. 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.

12. 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.

13. 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.

14. 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.

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

16. Within each of the first 5 Alternatives, both a habitat protection (enclosed circular formation) and an enhanced fishing design (straight lines) are presented. A total of 11 alternatives are then proposed.

Impacts

17. OSPAR and Norwegian national legislation, contain provisions that allow for the creation of artificial reefs, providing they do hinder other users and do not cause significant pollution.

18. Providing that some compensatory benefits or improvements are likely to accrue, some limited impacts may realistically need to be accepted.

19. The negative impacts of protection reefs were less than for fishing reefs. The former is therefore recommended.

20. Sites at Albuskjell and Eldfisk were preferred to the Centre complex area.

21. Toppling *in situ,* though the least favourable of the environmental options analysed, may well be the cheapest and safest and as such can not be discounted.

22. Oil components containing PCBs, halons/freons, persistent synthetic substances production chemicals and radionuclides should be removed. Topside tanks and pipe-work should be cleaned as thoroughly as possible to remove residual sediments.

Management

23. Reefs can be aimed to benefit either fisheries management, fishing or the environment / ecosystem.

24. Platform reefs can then basically be used to either assist commercial fishing, or as a protection zone (not both at the same time).

25. A rough estimate using published data suggests that an average 150,000 m^3 steel jacket on Ekofisk would be expected to hold about 45 tonnes of fish, though not all would be commercially usable.

26. If all structures on Ekofisk were created into reefs as planned, a total of 1,050 tonnes of fish may be attracted into a small area.

27. It is not known how quickly these would be replenished if the reef was fished out.

28. There is precedent for such closed areas, which are strongly recommended by some fisheries managers and nature conservationists. Platform reefs may be possible to incorporate into the current review of the Common Fisheries Policy.

29. An Ekoreef Management Group is proposed.

30. It is also recommended that no reef be established without a management and assessment framework in place prior to implementation.

Monitoring

31. An integrated programme of work is proposed, with an emphasis on commercial fish, because these animals are perceived as the most significant from an exploitable resource viewpoint.

32. The programme would involve periodic offshore surveys and sampling from a vessel. There would also be routine, longer term monitoring by remote equipment on the seabed or on the platform.

Communications

33. Information to, and feedback from, various stakeholder groups needs to be considered in the decision making process.

Alternative use

34. In keeping with the ecological nature of the use of the Ekofisk Tank as an artificial reef component, the following joint alternative uses may be possible: an alternative energy research and development centre; a centre for research, harvest and processing of marine resources; a communication and infrastructure component; a site for re-injection of waste

from the Tank into the reservoirs, e.g. CO_2 gas, drill cuttings or other non-desirable waste products.

Overall

35. The conversion of decommissioned jacket structures into complex artificial reefs is a viable and serious concept.

36. There are structures and locations within the Ekofisk region that would be suitable for such reefs.

37. Negative and positive impacts of these reefs would be expected.

38. On balance, evidence and conjecture suggests that habitat and stock protection reefs may be more beneficial than fishing reefs.

APPENDIX 1.1: Reef alternatives - GIS maps

For each scenario, 2 aims, and therefore designs are envisaged:

- (f) = fishing enhancement;
- (p) = habitat / environmental protection.

A total of 11 alternatives are proposed and visualised using GIS (Geographical Information System) technology. The new Ekofisk 2/4-X and 2/4-J facilities are included in all scenario figures.

The key to the colour code used on the Figures is presented in Figure 1.9 below. The contamination concentration and distribution for Total Hydrocarbon (THC) concentration are from sub-project 1, Appendix 1.1. The colour code for platform size is also presented in Figure 1.9.

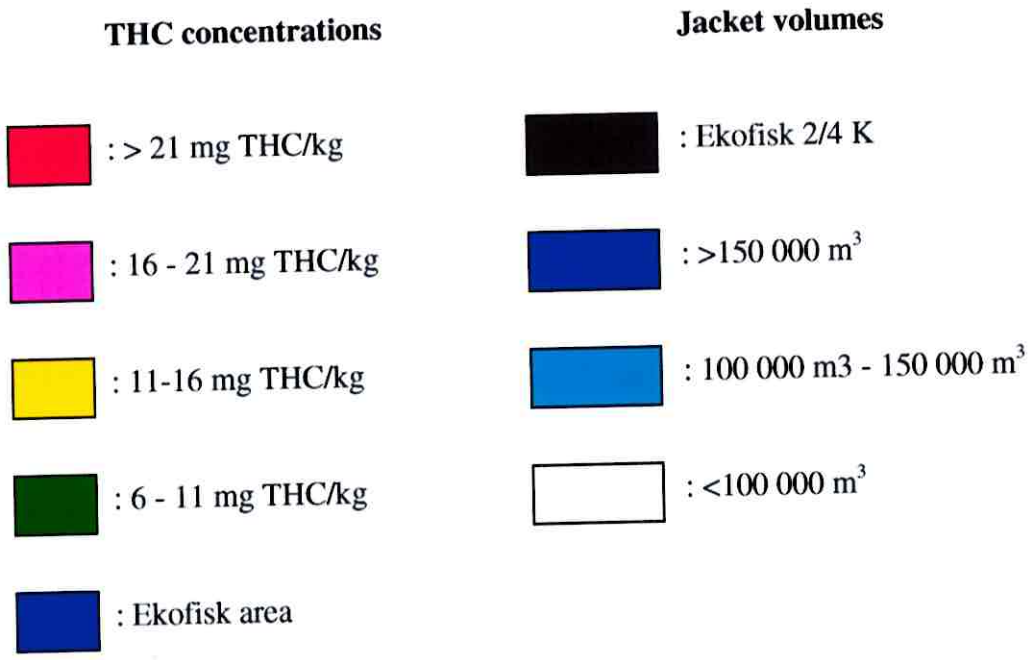


***Figure 1.9**: Colour code for THC concentrations and platform sizes shown in the GIS charts.*

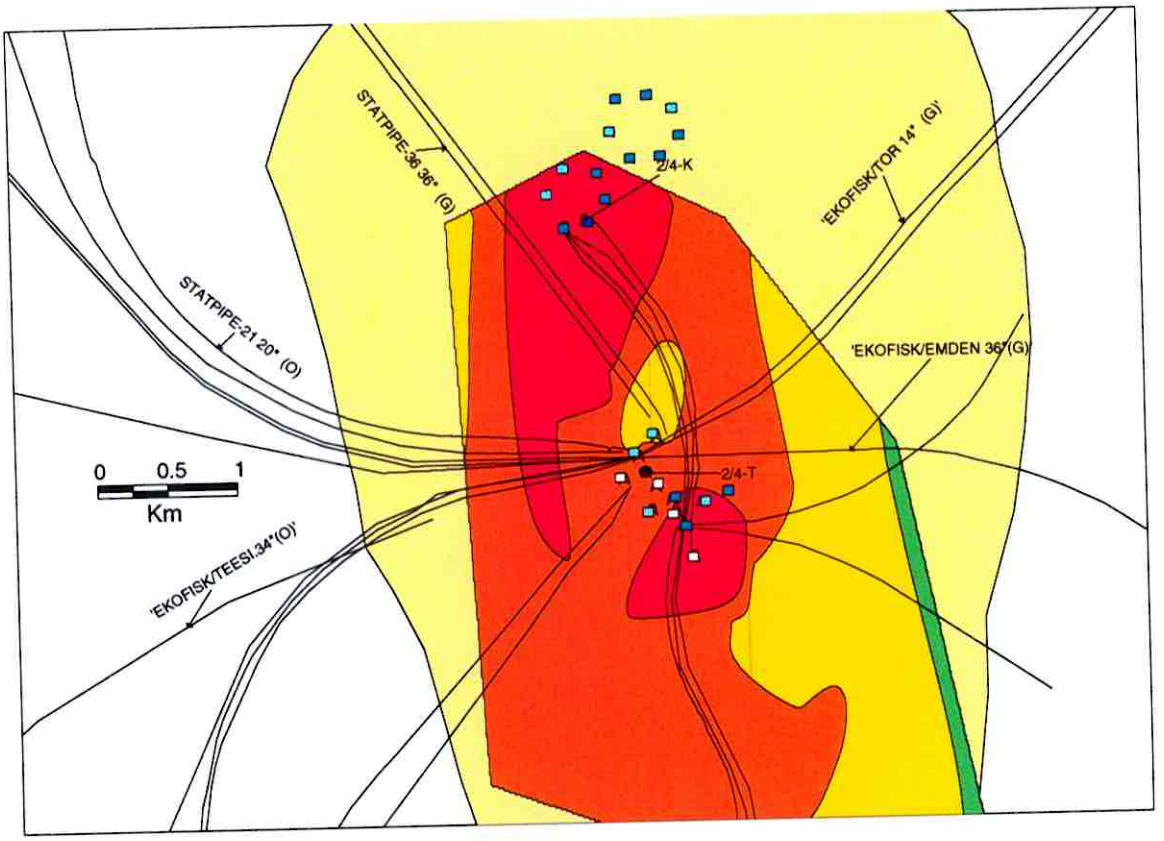


Figure 1.10: *Reef Alternative 1(Centre), for habitat protection.*

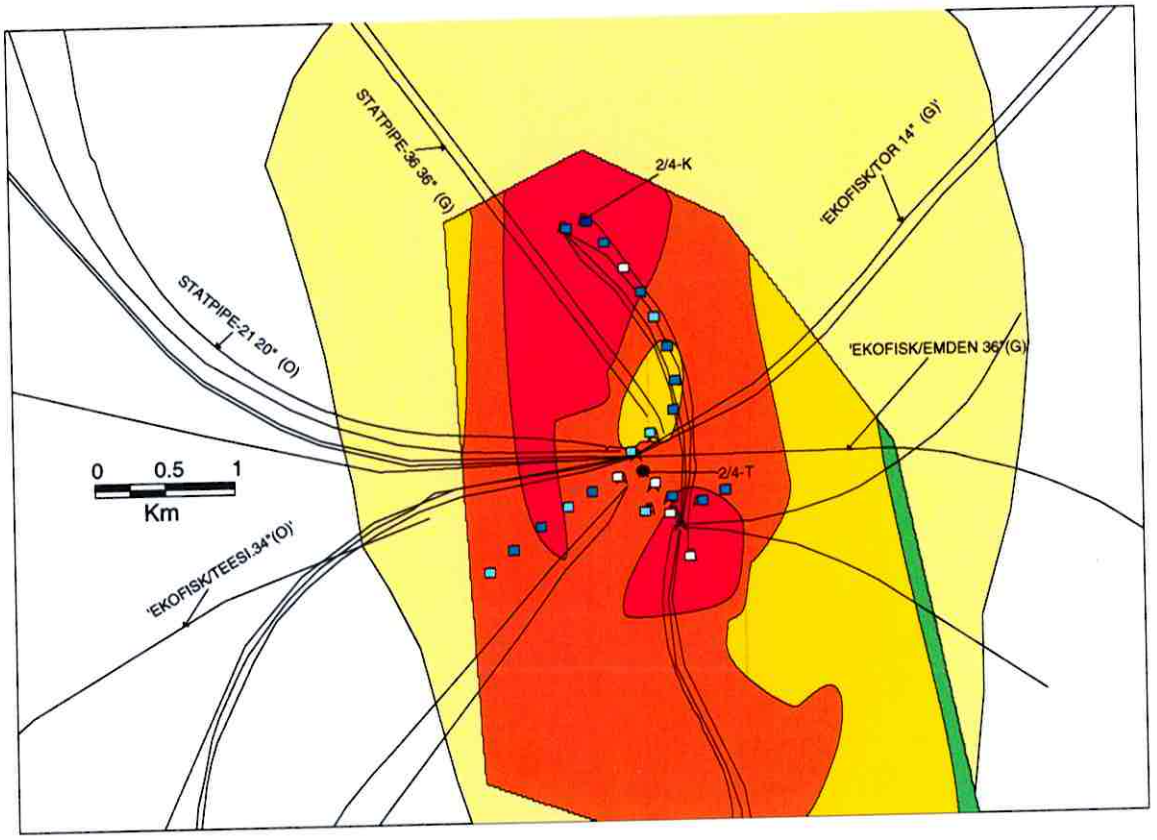


Figure 1.11*: Reef Alternative 1(Centre), for fishing enhancement.*

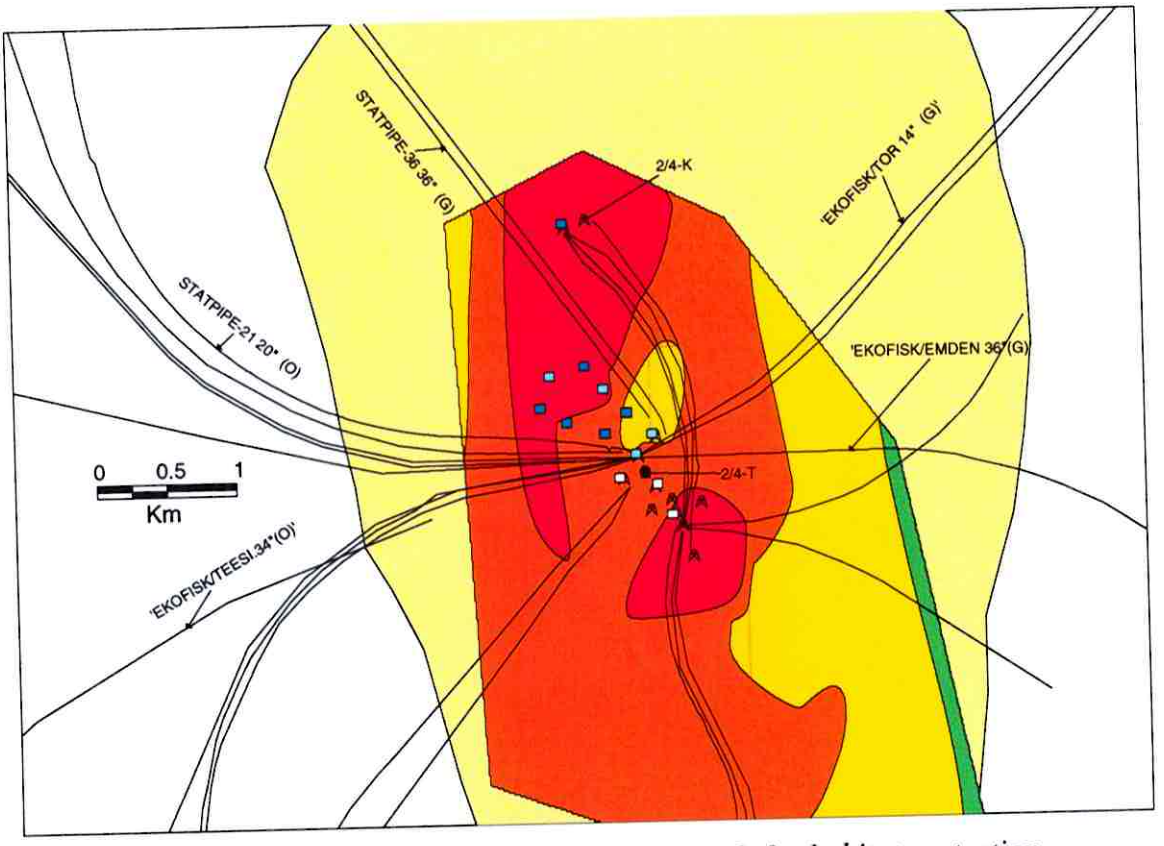


***Figure 1.12**: Reef Alternative 2(Tank), phase 1, for habitat protection*

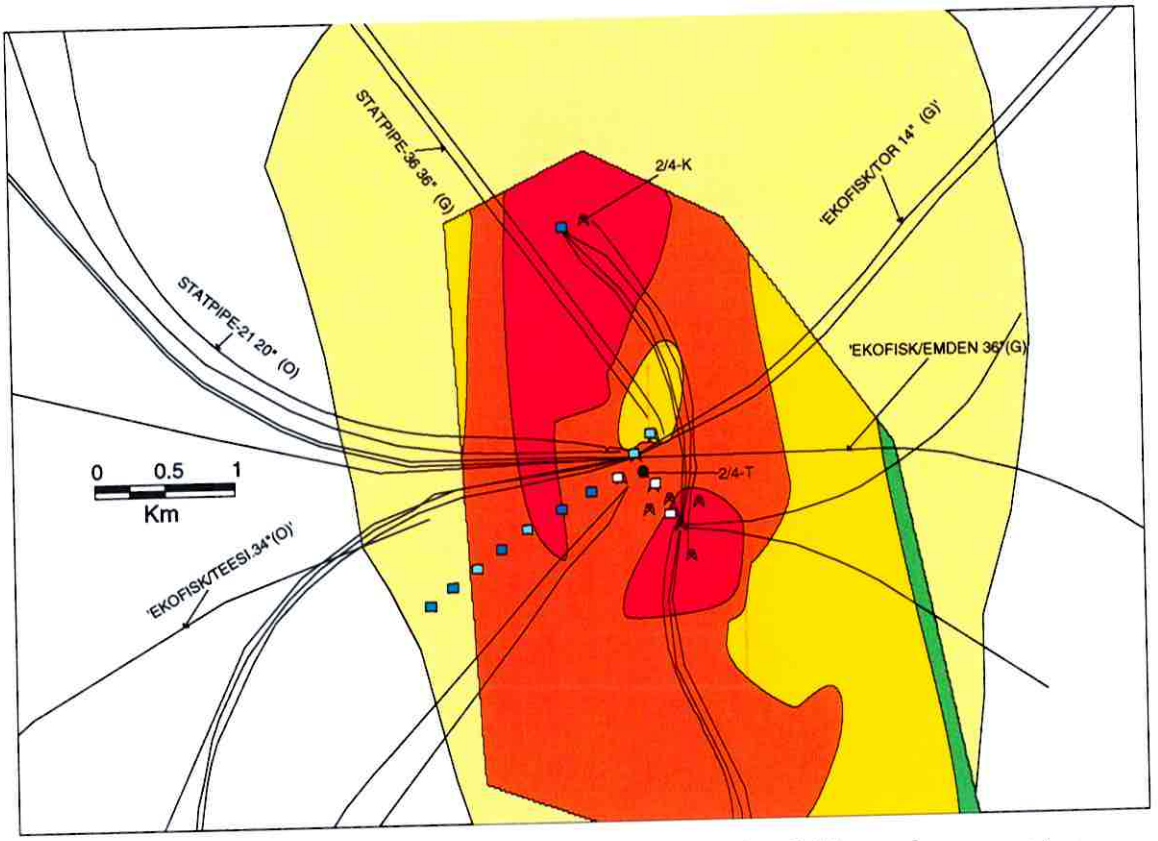


***Figure 1.13**: Reef Alternative 2(Tank), phase 1, for fishing enhancement.*

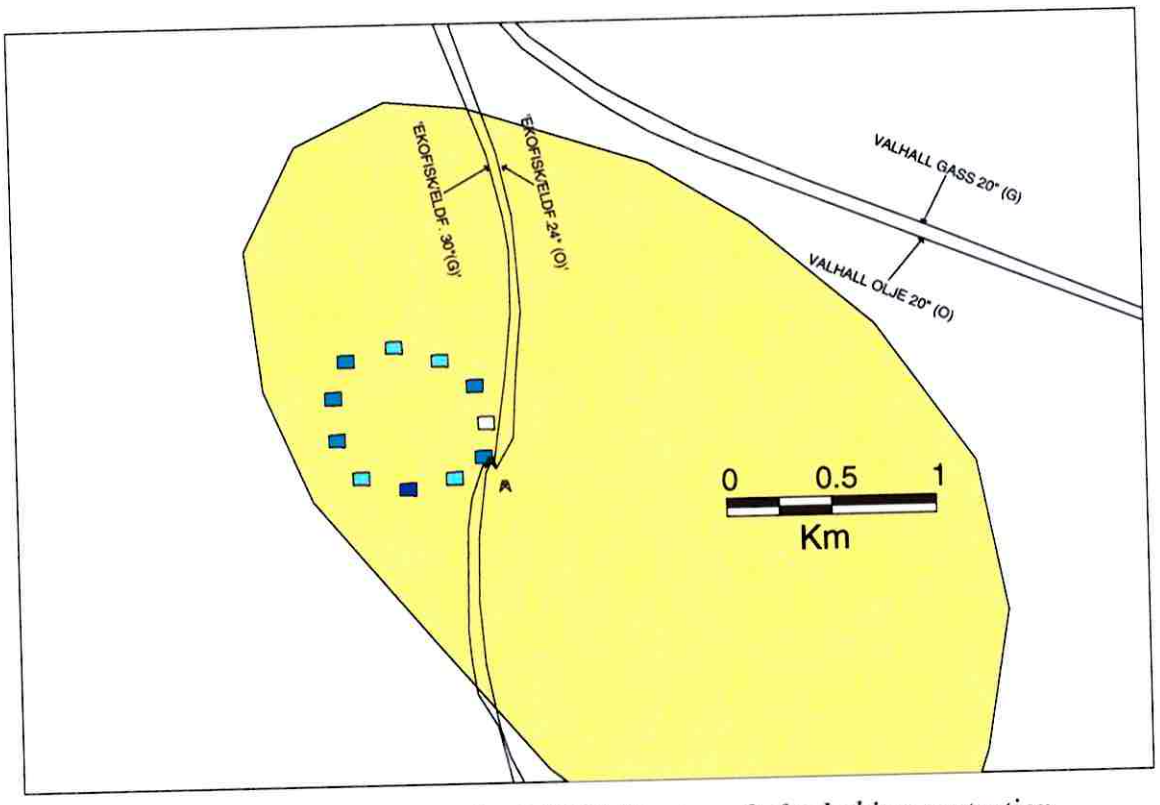


***Figure 1.14**: Reef Alternative 2(Eldfisk), phase 2, for habitat protection*

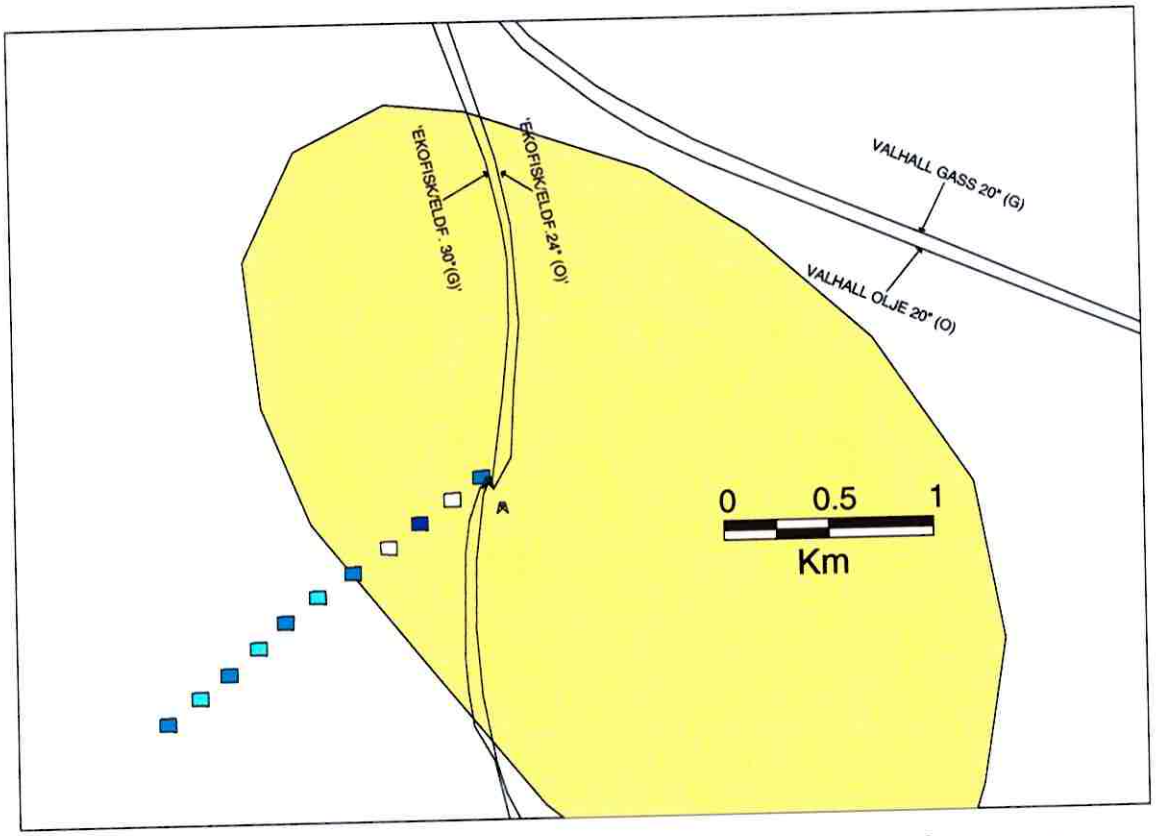


***Figure 1.15**: Reef Alternative 2(Eldfisk), phase 2, for fishing enhancement.*

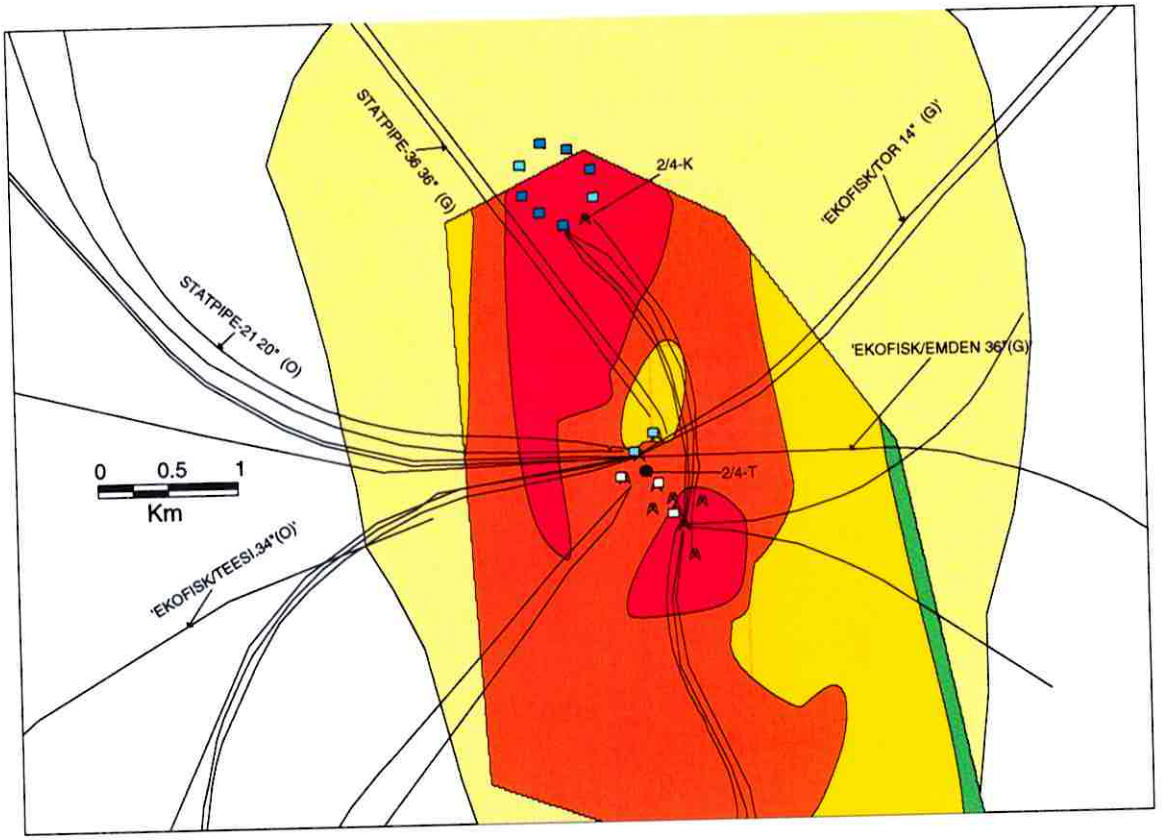


Figure 1.16: *Reef Alternative 3(Centre), phase 1, for habitat protection*

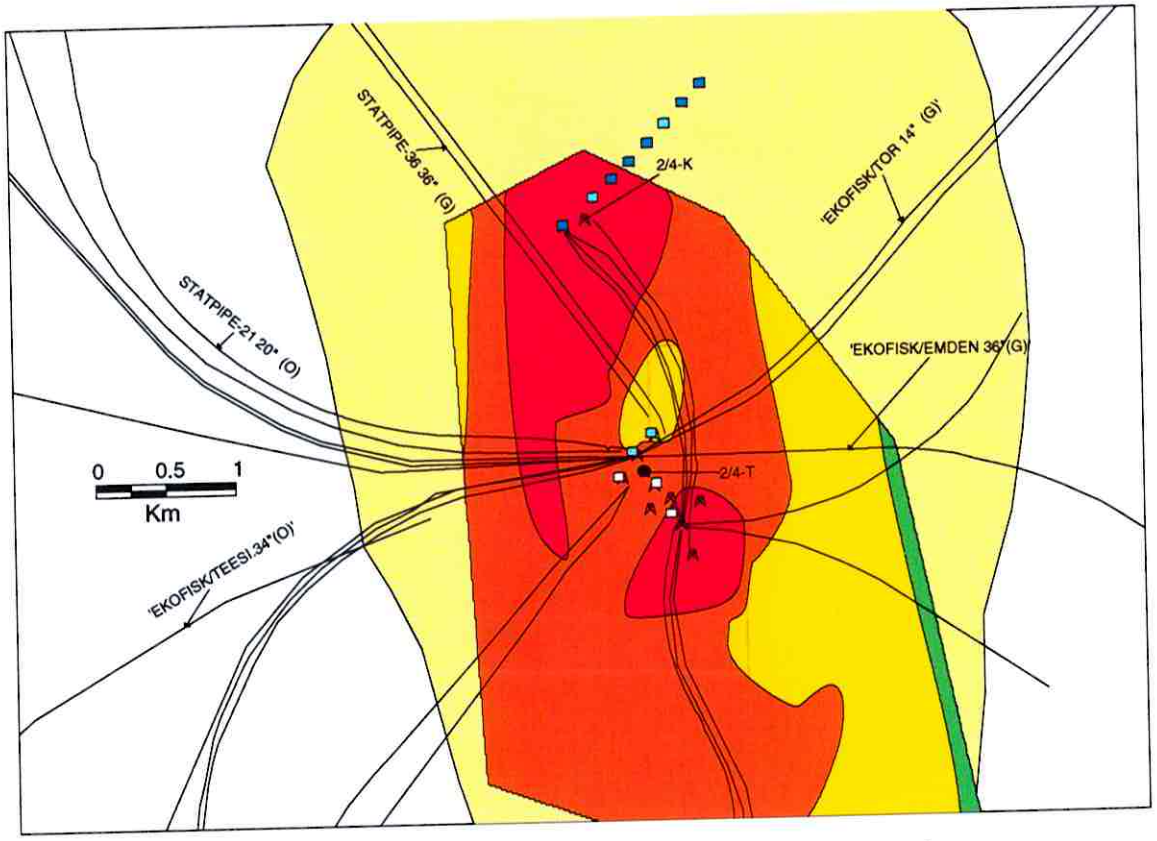


Figure 1.17*: Reef Alternative 3(Centre), phase 1, for fishing enhancement.*

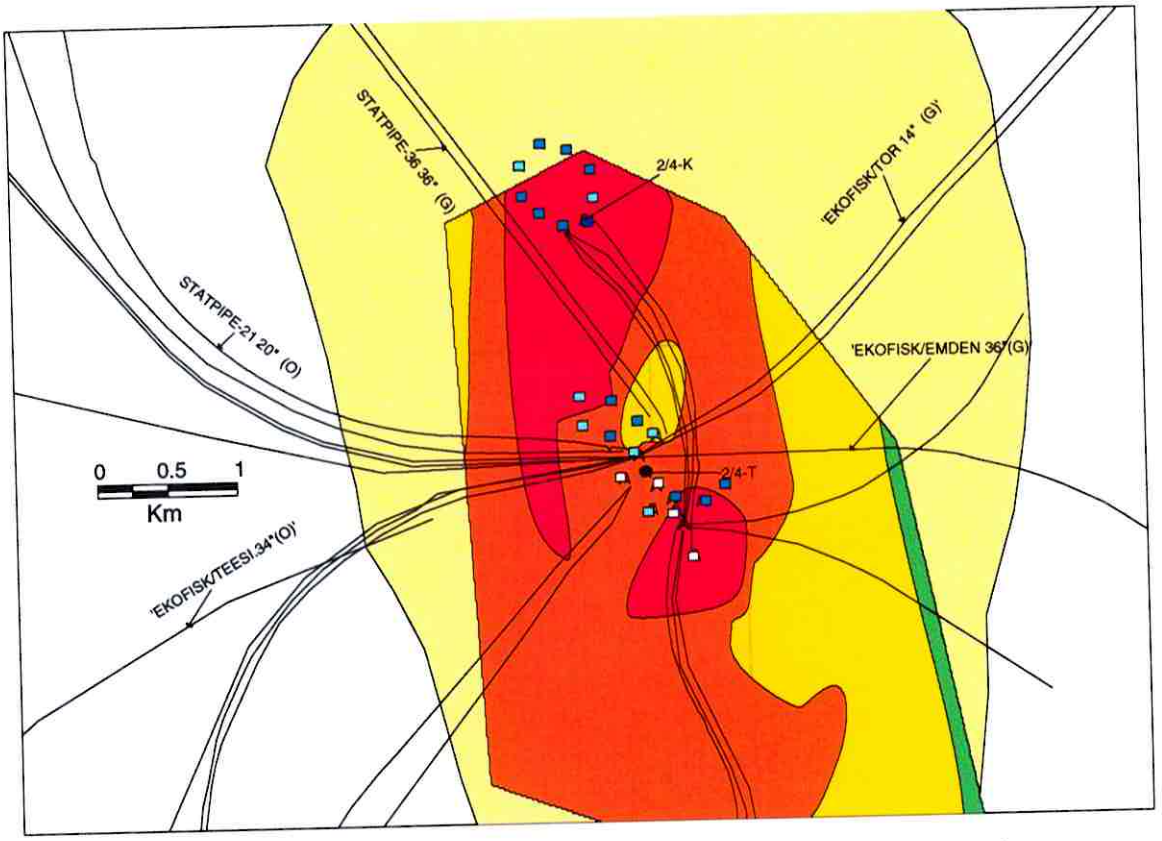


Figure 1.18: *Reef Alternative 3(Tank), phase 2, for habitat protection*

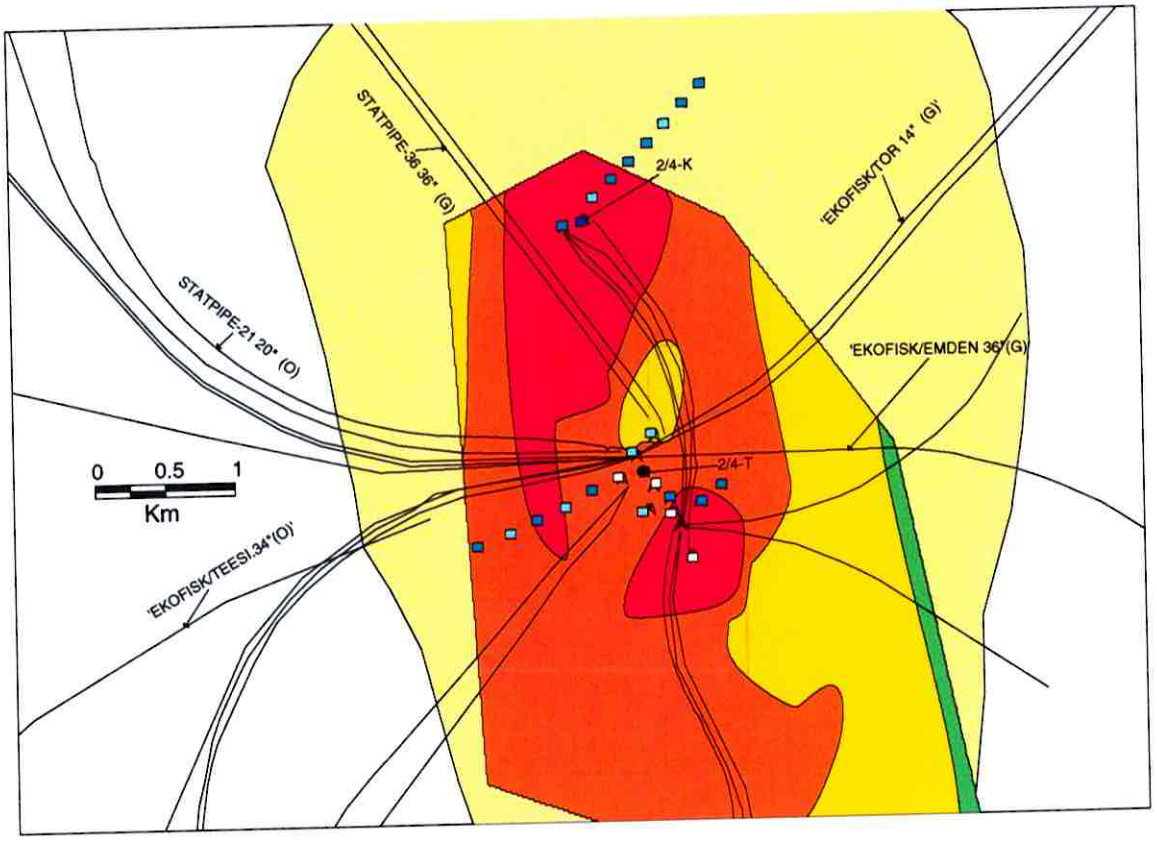


Figure 1.19*: Reef Alternative 3(Tank), phase 2, for fishing enhancement.*

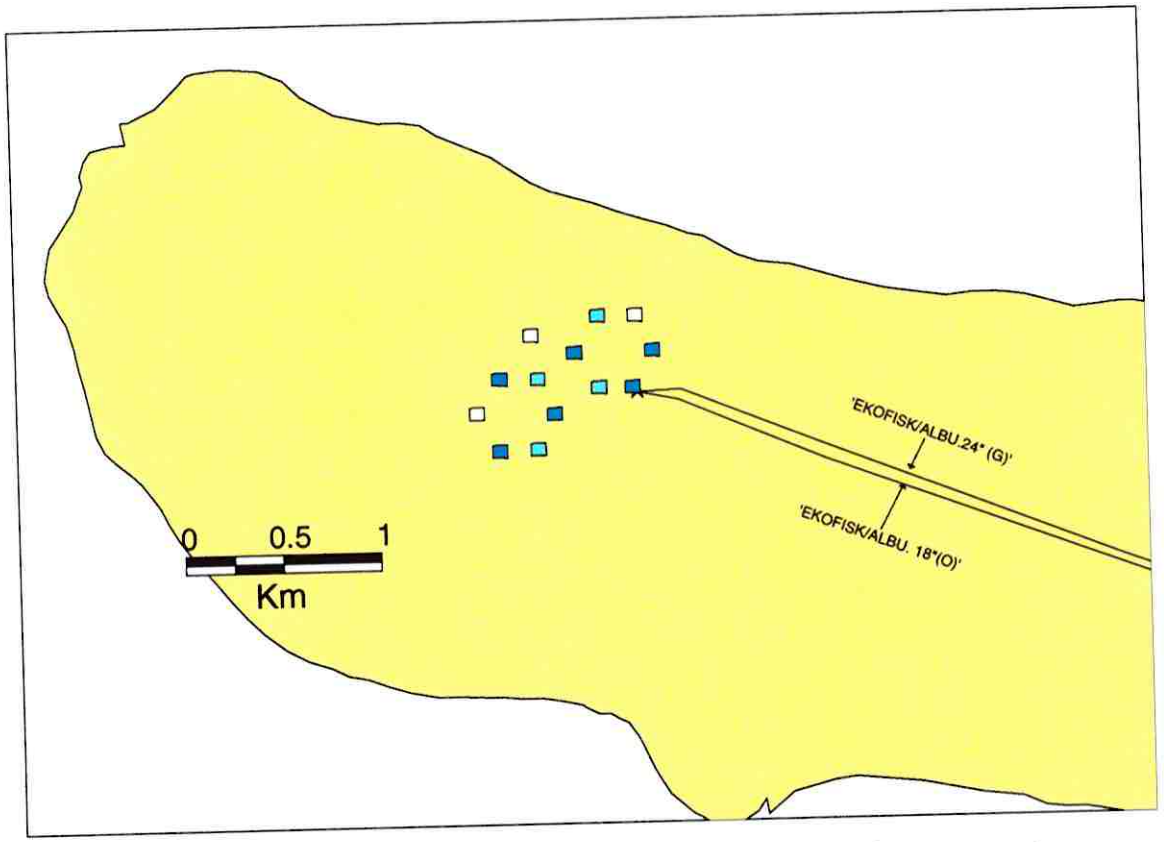


Figure 1.20: *Reef Alternative 4(Albuskjell), phase 1, for habitat protection.*

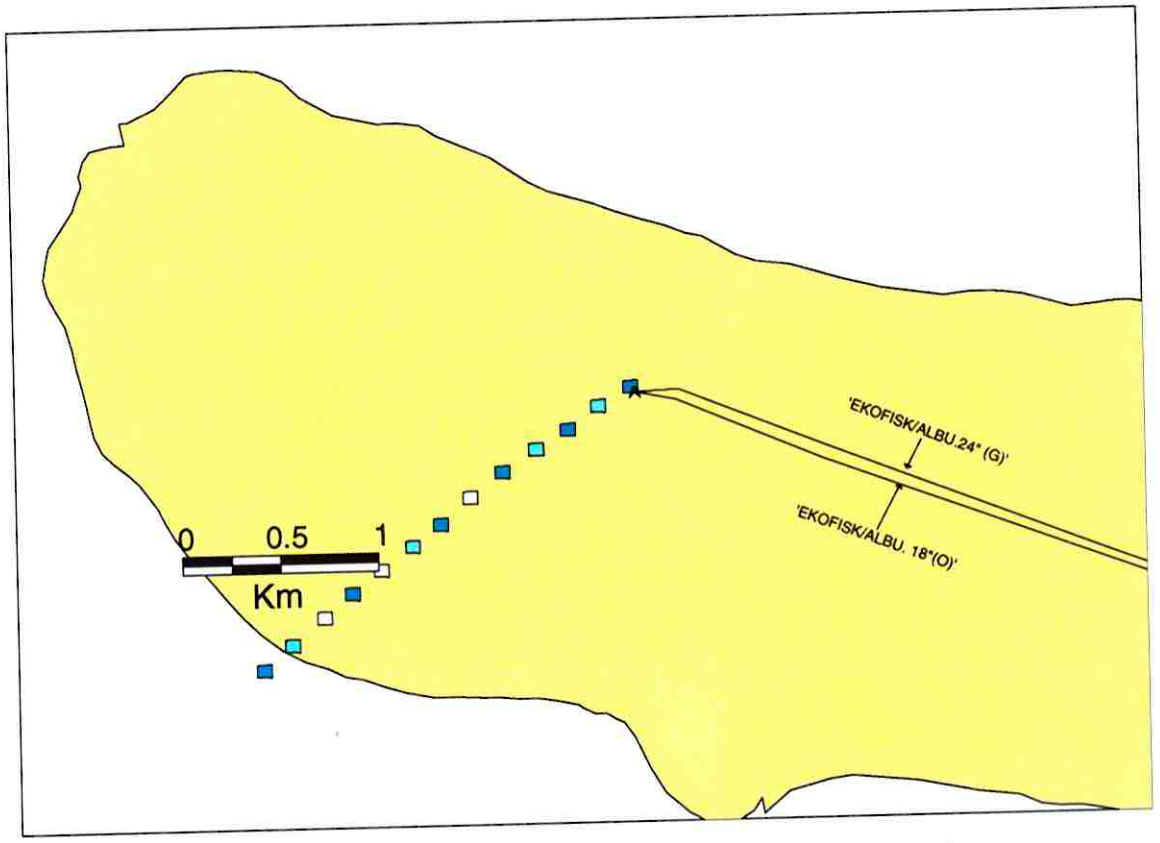


Figure 1.21*: Reef Alternative 4(Albuskjell), phase 1, for fishing enhancement.*

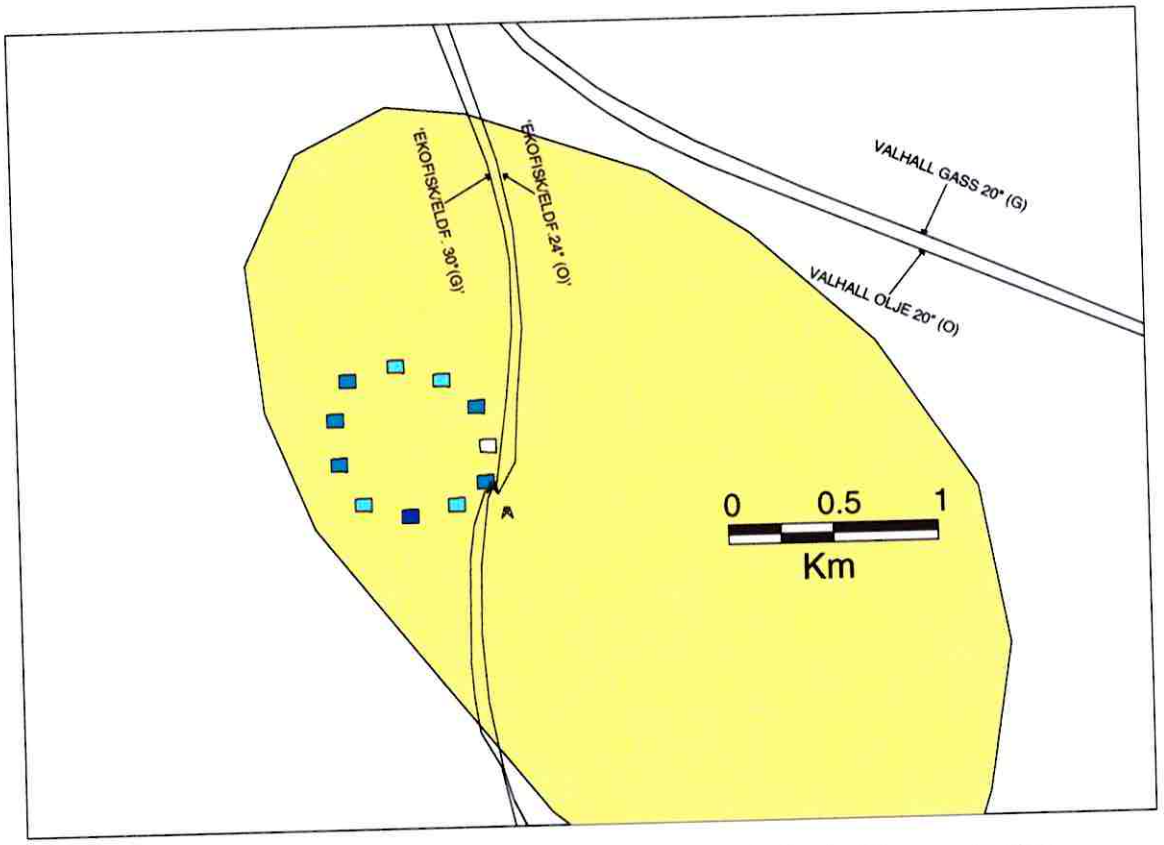


Figure 1.22: *Reef Alternative 4(Eldfisk), phase 2, for habitat protection*

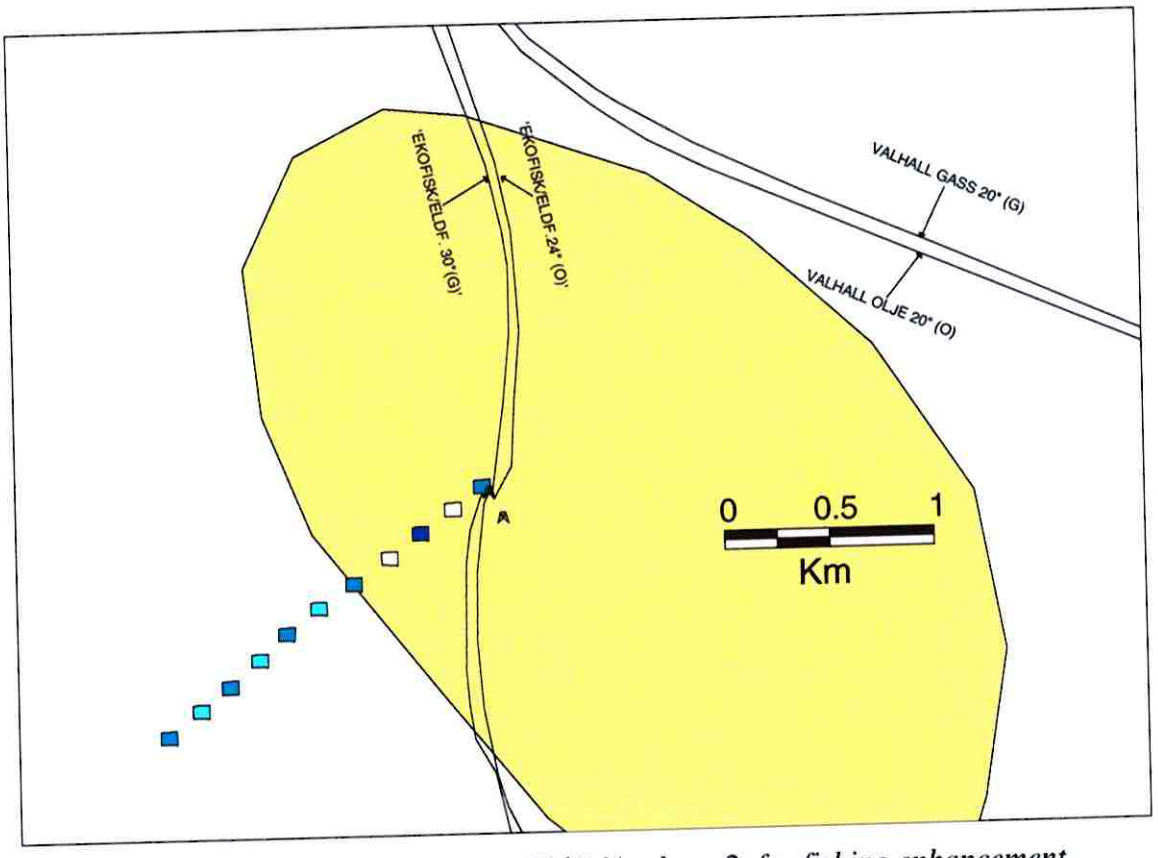


Figure 1.23: *Reef Alternative 4 (Eldfisk), phase 2, for fishing enhancement.*

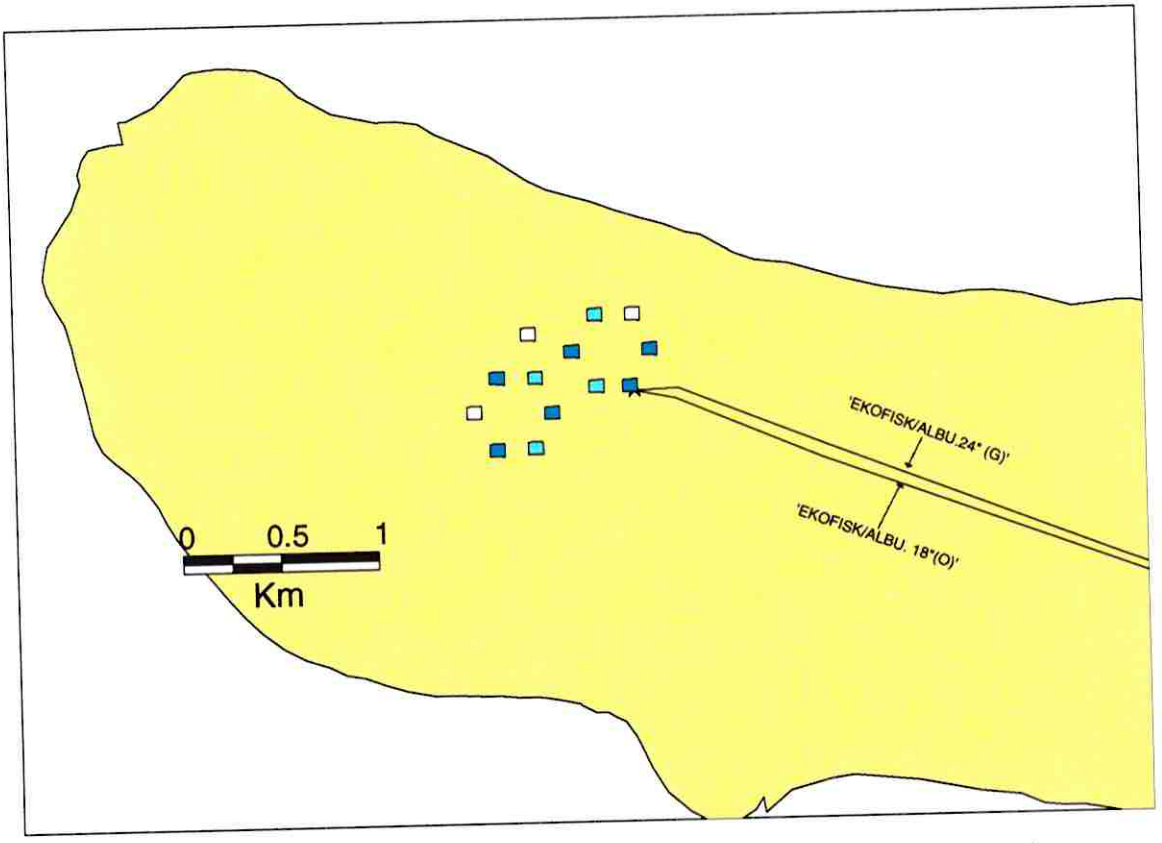


***Figure 1.24**: Reef Alternative 5(Albuskjell), phase 1, for habitat protection.*

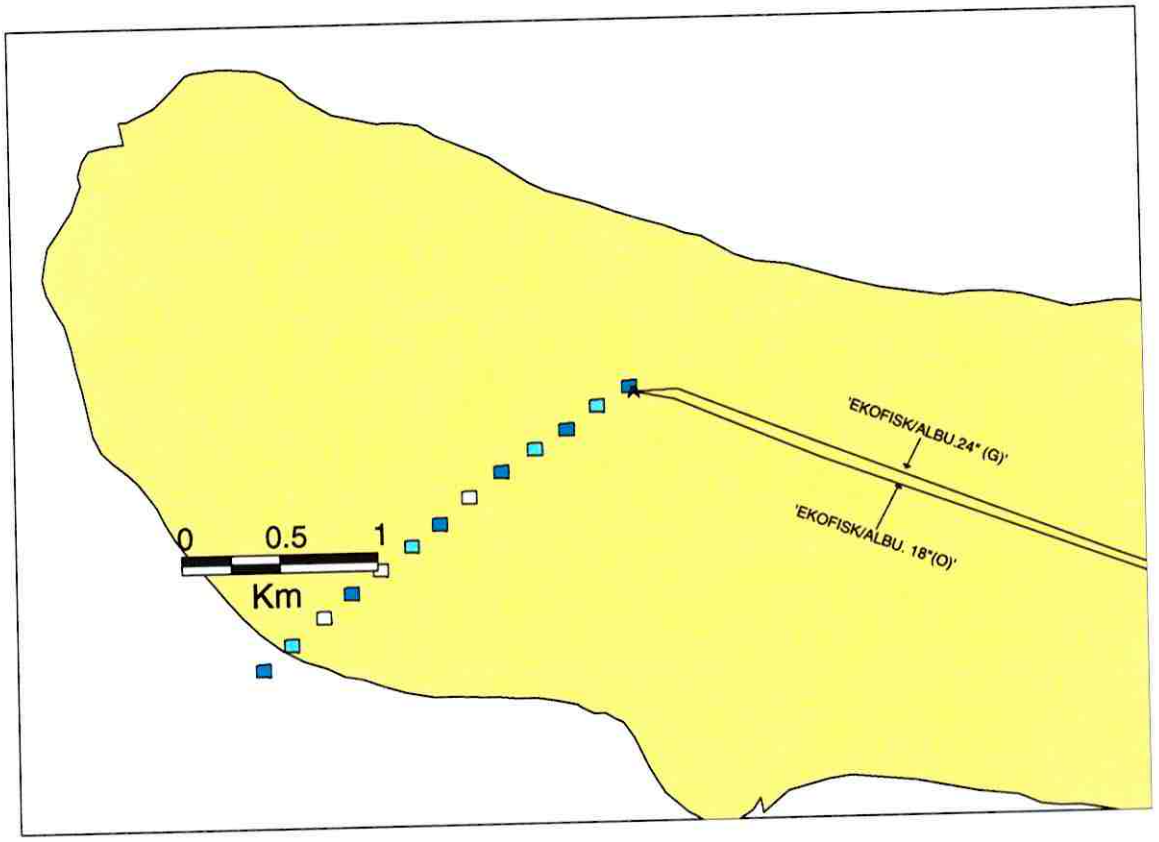


***Figure 1.25**: Reef Alternative 5(Albuskjell), phase 1, for fishing enhancement*

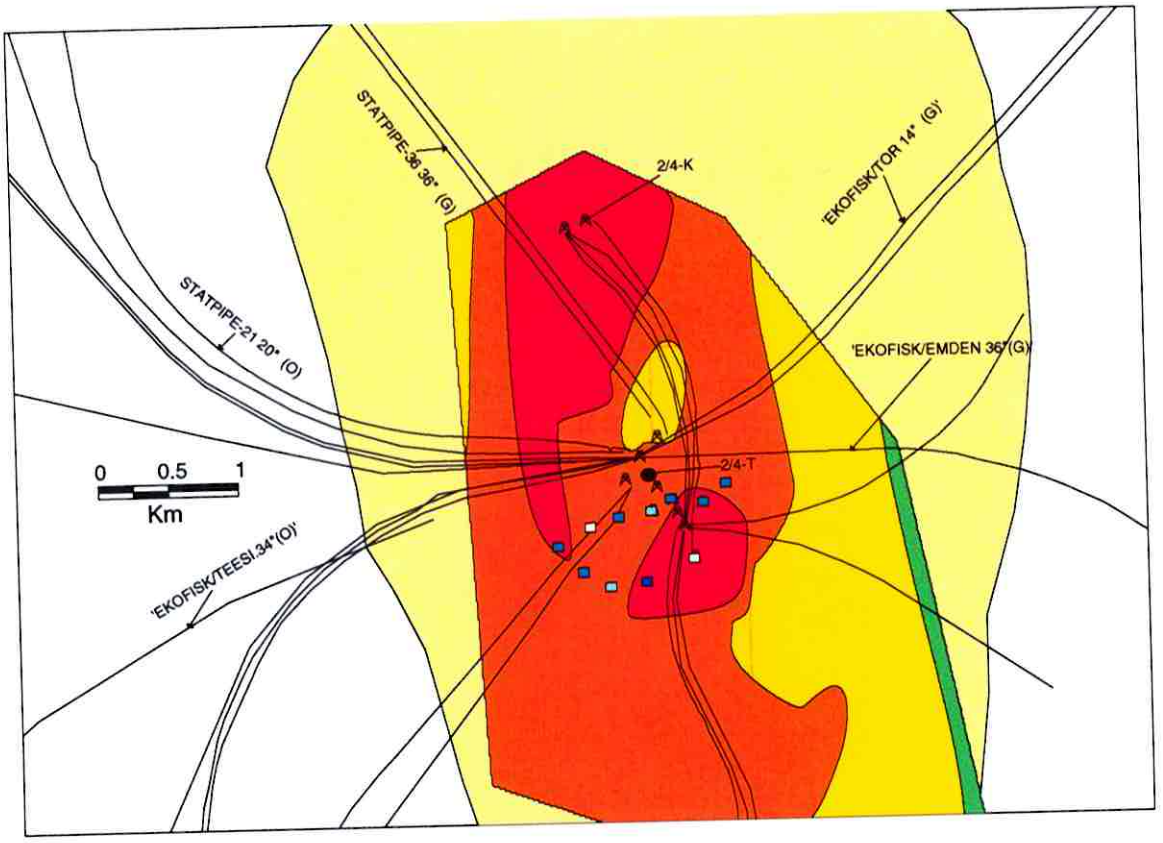


Figure 1.26: *Reef Alternative 5(Tank), phase 2, for habitat protection*

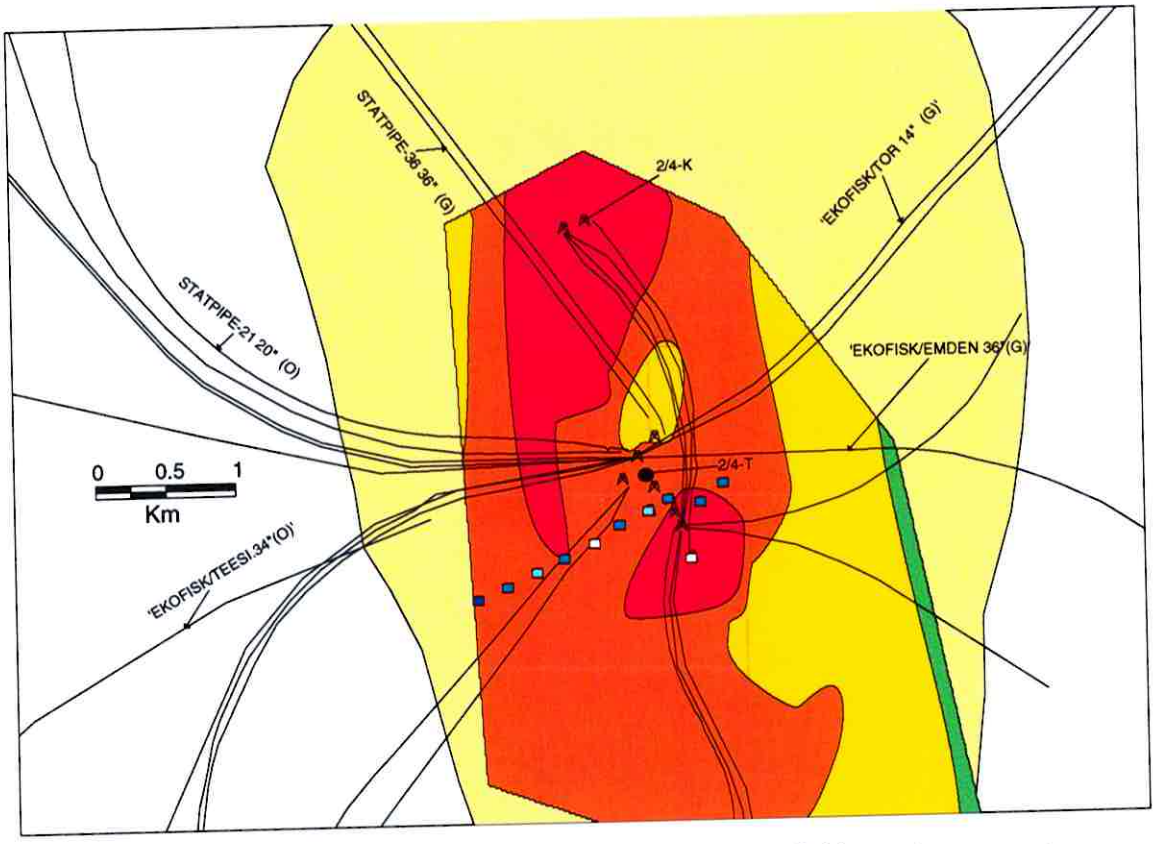


Figure 1.27: *Reef Alternative 5(Tank), phase 2, for fishing enhancement*

APPENDIX 1.2: 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