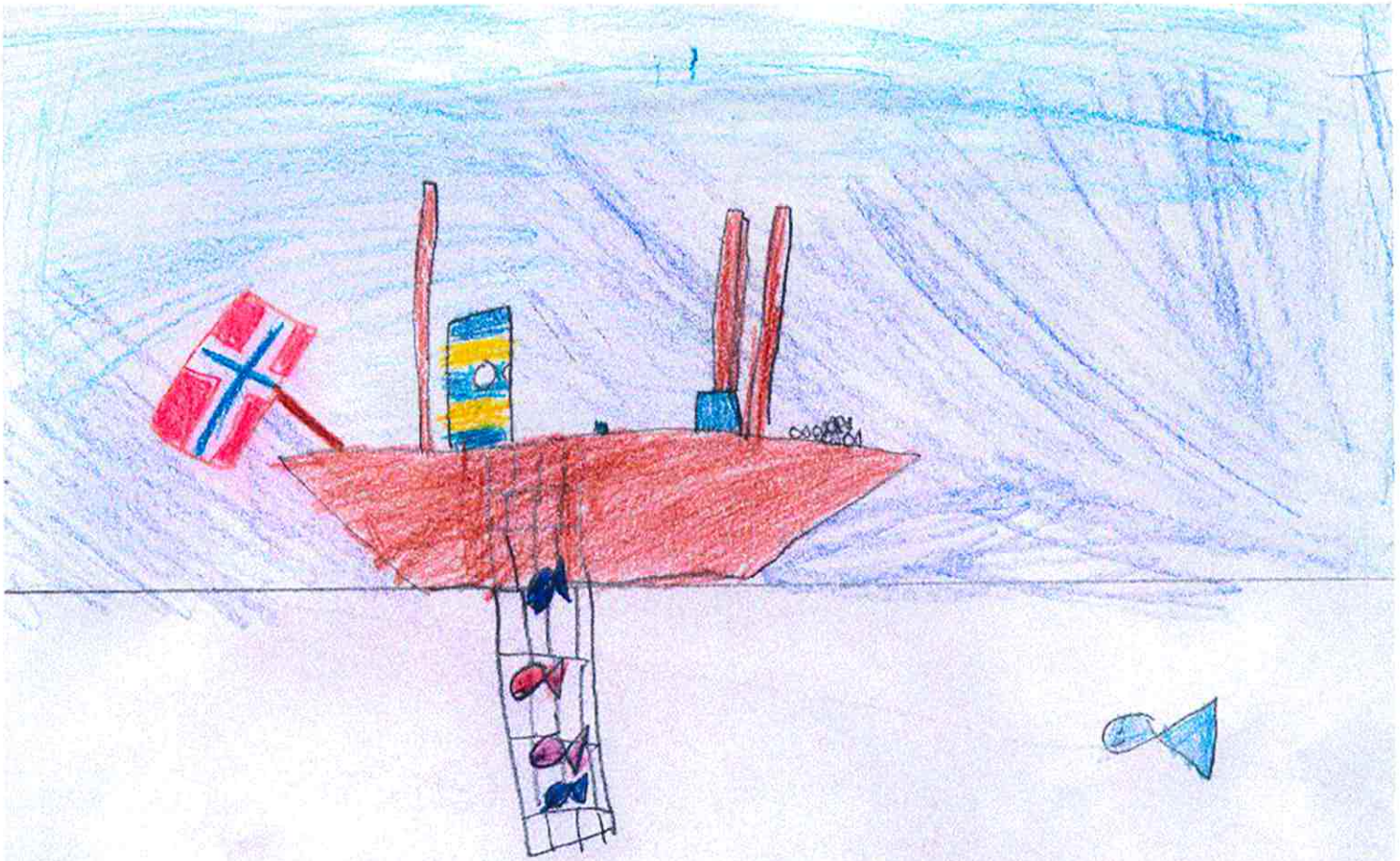


EKOREEF

Report 6: Monitoring programme

By

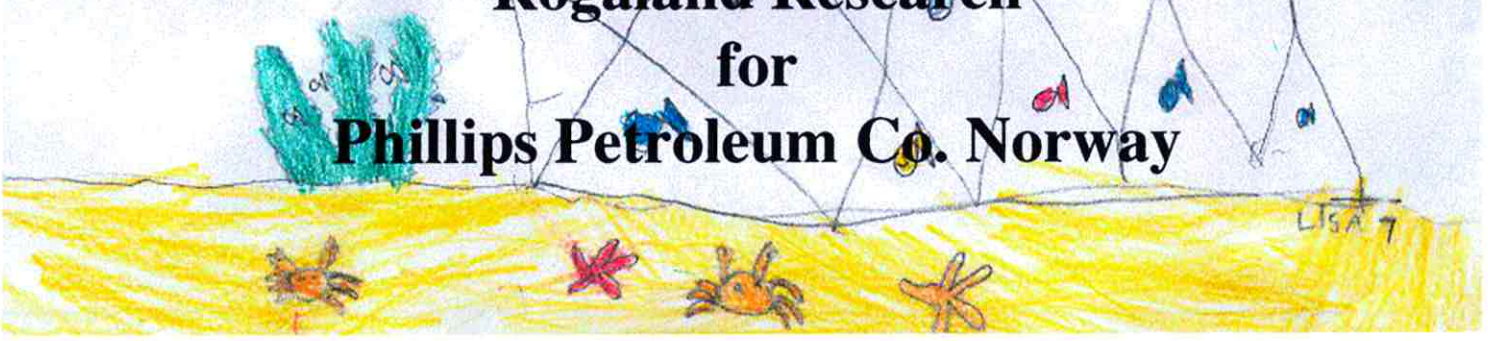
Dames & Moore

&

Rogaland Research

for

Phillips Petroleum Co. Norway



EKOREEF - Report 6: Monitoring

Report D&M 37363.001 - RF-98/020

Our reference:	Author(s):	Version No. / date:
DM37363.001/7 RF/771/654463.7	**Jacobsen, M.[2], Aabel, J.P.[2] and Cripps, S.J.[1]**	**Vers. 2 / 20-10-1998**
No. of pages: **17**	Project Quality Assurance.	Distribution restriction: **Open**
ISBN: **82-7220-948-9**	Client(s): **Licence PL018 through Phillips Petroleum Company Norway**	Open from (date): **01-01-2003**
Research Program: **EKOREEF**	Project title: **Report 6: Monitoring**	

Scope:
A follow-up monitoring and evaluation plan to assess the use and functioning of an artificial reef at Ekofisk is recommended. Experiments or surveys to obtain quantifying data that are currently unknown and which are required for management, assessment or prediction purposes are proposed. The programme should cover a period of at least five years to assess the colonisation and succession patterns on the reef. The data obtained through this monitoring programme will provide an input into the development of a fisheries model for the reef, a social and economic cost-benefit analysis, an ecological analysis of the spatial utilisation of the site, an ongoing assessment of the environmental effects, and a GIS database for managing the environmental and socio-economic data, trend evaluation and forecasting.

Key-words:
Ekofisk tank, monitoring, artificial reef, Ekoreef, decommissioning.

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CONTENTS

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 fifth project (report 6) 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	Ekofisk B and K
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.
Epifauna	Animals living on the surface of a structure or sediment.
GIS	Geographical Information System.
Infauna	Animals living within a sediment.
Pelagic	Pertaining to the water column.
SFT	Norwegian Environmental Protection Board.

6 EKOREEF Report 6: Monitoring

6.1 Summary

This report of the Ekoreef project provides an overview of the monitoring elements that should be performed during a monitoring programme over the first five years. The monitoring elements also include 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 for the Ekoreef are as follows (Aabel *et al.*, 1997):

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 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.

6.2 Introduction

6.2.1 SFT regulations for operating platforms

The contaminating discharges from the petroleum industry have changed during the past few years and it is important that the government have full control over these changes and the impacts they have on the environment. The SFT (The Norwegian Pollution Control Authorities) have therefore issued guidelines for environmental monitoring of petroleum activities on the Norwegian shelf. The guidelines contain instructions for execution and reporting of the environmental monitoring imposed on the operating companies, as part of the discharge permit.

In order to compare the results from one year to another, a set of fixed stations must be chosen. The stations are normally placed on the lines of a cross, where the centre of the cross indicates the contaminating source. The axial cross is placed according to the dominant currents in the area, and the closest station should be 250 m from the contamination source. The reference stations have to be placed at least 10 000 m upstream from the source, and have to be representative for the area.

A number of parameters has been set in the guidelines by the SFT. In the water column this mainly includes biological evaluations and the amount/concentration of different hydrocarbons. The sediment analyses are more extensive. In addition to biology and hydrocarbon analyses, the presence of some of the most "dangerous" metals should be determined (Cu, Zn, Pb, Cd, Hg, Cr, Ba and Fe). A thorough description of the sediments is also included in the guidelines. The SFT can, at any time, extend the monitoring programme. The operators are expected to identify and solve any potential problem that may be caused by the discharges. Through research and surveillance, the operators are expected to be in front of the guidelines from the SFT.

These guidelines could also be a basis for the environmental monitoring of an artificial reef. If possible, the monitoring stations for the artificial reef should be the same as those in the operational phase. It is however important that the sites within and around the reef are "clean" and that the organisms living on the reef do not suffer from any negative impacts as a result of any contamination. In order to monitor the development and effect of the reef, it will be necessary to perform additional sampling and analysis of the fish and other biomass. Section 6.5 will present an overview of some of the available methods for monitoring of the marine life. On the basis of this, and the guidelines from SFT, a monitoring programme is proposed and presented in Section 6.6.

6.3 Background

6.3.1 Shipwrecks as models

It has been suggested on several occasions that a study of the shipwrecks in the North Sea would provide valuable information in the assessment of jackets as artificial reefs. Within an area of 500.000 km^2, which covers most of the North Sea, the Hydrographer of the Navy (Wrecks Department) has catalogued 8,000 wrecks with a weight of more than 25 tonnes. Not all of these wrecks however, are suitable as sites to investigate the effects of reefs. The wrecks would have to be located in the central or northern sectors of the North Sea, and would have to be located at depths greater than 65 m. It would also be important that the wreck was made of steel (not wood), and that it weighed more than 1,000 tonnes. 22 such wrecks are covered by these criteria, excluding

Piper Alpha and the drilling rig Transocean 3. Some of the wrecks date back to 1914 (Aabel *et al.*, 1997).

Even though some of these wrecks could provide some of the characteristics of an artificial reef, there are some drawbacks in comparing them with artificial reefs made from jacket structures. Firstly, shipwrecks consist of large horizontal plates of steel, which often collapse partially or totally in on themselves. This does not provide a good approximation to the open structures of a jacket. The enclosed volume, which is accessible to fish, is also small compared with a jacket. Secondly, it is possible that the wreck has been or is being fished, and this makes it difficult to assess how large the natural population of fish is close to the wreck. Most importantly, the fishing activity may have caused the wreck to be snagged by nets which have been discarded but are still "ghost fishing". This ghost fishing results in the presence of dead and rotting fish, thus making the reef unattractive to other fish and is therefore likely to reduce the efficiency of the reef. It seems likely that any offshore studies would be best focused on existing non-operational platforms (Aabel *et al.*, 1997).

6.4 Non-operative platforms as models

In order for a platform to be used as a model for an artificial reef, the platform should be in the cold phase, i.e. non-operational. It has been questioned in several papers whether factors such as light, noise, vibrations and/or waste could explain the accumulation of fish around a structure. Recent studies (Cripps and Aabel, 1995) have demonstrated that non-operating jackets also attract fish in large numbers. It might also be easier to get access to the safety zone if the platform is in the cold stage.

In order to avoid interference that could mask the scientific results, there should be a minimum distance of at least some kilometres to the nearest operating platform. However, the distance to the operating platform should not be too far, as this may exclude the use of support vessels from these platforms. The jacket should also have an accessible deck structure where necessary scientific recording and sampling equipment could be mounted or stored.

These are some of the criteria for a full-scale experiment on artificial reefs in the North Sea. Several areas in the North Sea are in accordance with these specifications. One possibility might be Albuskjell with the platform 2/4 F as a centre for the study. This platform was shut down several years ago. The jacket weighs approximately 7,300 tonnes (piles included) and has a volume of 182,000 m^3. The distance to the nearest platform (1/6 A) is 8 km and the distance to the Ekofisk Centre is approximately 13 km. This makes the 2/4 F platform an excellent base for performing a full-scale scientific experiment.

6.5 Monitoring elements

This chapter summarises the practical work which will have to be performed during the programme. Some of the elements provide background information concerning food availability, shelter, presence of contaminants and hydrology. Other elements are directed towards the commercial fishing and the socio-economical role of the reef.

6.5.1 Water column

An important factor in the creation an artificial reef from platforms is the water movement at the chosen site. The physical presence of the platform structure may disrupt the flow of water and thereby provide shelter for the fish. It may also create eddies to disorientate prey species, thereby

creating a feeding advantage for the fish. Both of these factors serve as a benefit for the fish, giving the fish a bioenergetic advantage because they might not have to swim so hard. In addition to being a possible benefit to the fish, the water movement may also be a factor influencing epibiotic (surface living organisms) settlement on the platform structure and survival on the surface of the jacket. It is uncertain whether the epibiota serves as a food source for the fish, but it will be an important part of the reef community as a whole.

Water movement can be measured in different ways and linking fish position (from telemetry) with water column movement and stomach contents analysis will provide a unique insight into the way the jacket structure is used by the fish and help in assessing whether swimming in the vicinity of a jacket does provide benefits to fish in terms of, for example, growth potential. Dissolved nutrients in the water column should also be monitored because this will give an indication of potential phytoplankton growth.

6.5.2 Sediments

The sediments close to a reef, made from platform jackets, may suffer from contamination. During the operational phase of the platform there may have been discharges of oily drill cuttings which also contains heavy metals. Therefore, special care must be taken in finding the most suitable site for the reef. For petroleum activities on the Norwegian shelf, the SFT has issued a set of guidelines for environmental monitoring. These guidelines also include a total study of the sediments, and should act as a basis for the monitoring around the artificial reef. Samples are most easily taken by a remote grab, which will sample the sediment to a depth of about 15 cm. The samples taken should be analysed for the following parameters:

- *Sediment metal concentrations* - to assess if there are any gradients of effect centred on the platform and its anodes. In the absence of a cuttings pile, the steel structure and anodes would appear to be the only source of such anthropogenic inputs. It would be valuable to attempt to determine anode-related inputs to sediments.
- *Sediment hydrocarbon concentrations* - to assess if there is any gradient (to ensure that there is not), but also to provide site-specific data for the platform. It is known that hydrocarbon concentrations in sediments have risen in parts of the North Sea, specifically as a result of oil and gas activities. Examination of a non-drilling site would provide some data relevant to this question.
- Particle size characteristics - to determine the nature of the seabed and one of the significant influences on the composition of benthic communities.

6.5.3 Plankton

Plankton form the basis of the food web for marine animals. Some assessment of population structure through the water column is needed to provide baseline information on the variation of available plankton. This comparison will provide some indication of the plankton found at the surface and those found just above the seabed. When this is linked to benthic biomass data it will give an indication of the epifaunal biomass supportable on a toppled jacket, as opposed to a vertical structure.

Plankton is extremely variable and so vertical plankton net hauls and water samples for chlorophyll analysis will be needed during each cruise, during the night and day. Standard techniques and equipment have been developed for this purpose, and sampling zooplankton has recently been included as a part of SFT's surveillance guide for operating platforms.

6.5.4 Benthos

The deployment of an artificial reef could alter a pristine soft bottom community. The deployment of an artificial reef could produce, amongst other things, the following alterations in the surrounding substratum:

- the smothering of a portion of the soft bottom, under the reef base;
- modification of the bottom current and, as a consequence, variations in the sediment-size distribution and the silting rate;
- change of sediment organic content through the metabolic activity of both benthic and nektonic reef assemblages;
- an increase in feeding pressure on the infauna due to both attracted and resident reef fish.

When creating a complex reef, such as Ekoreef, large jacket structures will be placed on the seabed, thereby smothering the fragile benthic community. Locally, this might alter the composition of the infauna and thereby the food supply. The benthic communities will however probably be rapidly restored, and in the future the reef may serve as a protection zone from trawling activity. The present safety zone around operating platforms may mimic this effect, and previous benthic surveys may provide the required data to substantiate this. In order to monitor any gradient of effect on the benthos, a series of samples should be taken at different distances from the reef. It might also be possible to determine whether a gradient is caused by natural or anthropogenic sources. The site chosen for the clustered reef shall not have been subject to any recent deposition of drilling muds and it should be situated far from any operative drilling site. In such case, any gradient in the benthic community has to be caused by a natural source or the physical presence of the clustered reef and its associated effects.

Standard methods and guidelines for sampling have been established by the SFT (see above) and are presently used when sampling areas around operating platforms.. This will permit data collected at the reef site to be assessed against the large body of information already obtained from many platform and reference sites around the North Sea, and from other, non-oil related studies in the North Sea.

Sampling the benthos will demonstrate any impacts from an artificial reef on the benthic community.

6.5.5 Epifauna

There has been the suggestion that fauna on jackets of offshore platforms provide an additional food source for fish. Analysis of the stomach contents of captured fish may provide further evidence to support or refute this supposition. The fauna on the jacket are also of value in their own right and should be assessed in order to effectively describe the community and its nature conservation value, given that the steel substrata of the jackets are an unusual habitat in the North Sea which will be destroyed if the jacket is removed to land.

There is already a body of qualitative and quantitative evidence describing the fouling communities on many platforms throughout the North Sea and, in the past, samples of fouling communities have been taken by divers and examined. The information should be reviewed and the composition of platform reef epifaunal communities compared with other epifaunal populations to provide an indication of nature conservation value (and volume of fish food, if fish are found to be feeding off the reef epibiota). Of particular importance for the future assessment of communities on jacket based artificial reefs are the species present on the base of the jacket as it is these, rather than the communities close to the surface that will dominate the deep water reef surfaces. It would be

prudent to examine the fouling on the structure using ROVs during frequent surveys of the platform and its fish, with emphasis on the deeper portions of the structure.

6.5.6 Fish

As the most important and most discussed aspect regarding establishing of an artificial reef, will be the consequences for fish populations and fisheries, then the study of fish populations and fish behaviour around the reef will dominate the monitoring programme.

6.5.6.1 Density

Semi-quantitative estimates of the fish populations around an artificial reef and at a reference site are vital for estimating the significance of fish aggregations around a platform reef. Previous studies (e.g. Valdemarsen, 1979) used a variety of different fishing methods to compare the number of fish, while newer studies (e.g. ICIT, 1991) used acoustic methods. None of the methods exclude the other and several will need to be used together to survey a steel jacket.

Acoustic surveys should be conducted along transects from the jacket at the reference site. The distribution and number of fish will be observed and these techniques will allow an overall estimation of shoaling behaviour and size. To achieve data on individual fish, which are essential to an overall assessment process, acoustic telemetry will be used.

6.5.6.2 Physiology

It is of great importance to try to quantify the energy budget of the different trophic levels. It is also necessary to demonstrate if fish living in and around a structure feed on prey from the same area or just use the jacket as a safe haven and then feed in other areas. The following elements are therefore suggested:

Fish size, feeding, growth and contamination

Fish can be captured using hooks, nets or traps. Experience suggests that to obtain fish from close proximity to the platforms, this is best achieved by line fishing, with nets being next best. Traps have been used around platforms but with mixed success. For the purposes of examining stomach contents, fish caught at depth should be retrieved with care to the surface in order not to cause inversion of the stomach through the rapid expansion of the swim bladder. For all other purposes, the fish can be used whatever their condition. Care must though be exercised to avoid contamination of tissues during landing and preparation, if the fish are to be used for chemical examination. Detailed protocols for the landing, preparation and storage of fish and tissue samples have already been worked out and can be applied to this study without great modification.

Taint

A study of the flavour of selected species of fish at the site will be carried out to determine if any detectable taint is present in the reef fish. This will include:

- assessment of tissue contamination of a selected species;
- determination of the possible origin of the contamination found;
- assessment of the flavour of fish (tainting) by presentation to a test panel;
- investigation of any possible relationship between levels of tissue contamination and any taint detected in the fish;

- attempt to investigate the potential for chronic, low level contamination of reef fish flesh from sacrificial anodes on the structure.

Size frequency analysis

These data will allow a comparison of the physical dimensions of individuals in the fish populations in the vicinity of the platform reef with those at the control site. Logging of data with that of stomach contents analysis, age, growth rates and contamination will build up a full picture of fish condition. This is simply achieved by measuring and weighing each individual involved.

Instantaneous growth rate

The instantaneous growth rates of two species, saithe and cod, could be assessed. The most important implication of assessing instantaneous growth rates will be the need to set up laboratory control populations of fish which to determine baseline growth rates of fish fed known rations over time. Although baseline data is available for saithe, these would need to be repeated, and levels set for cod.

6.5.6.3 Residence time

Fish are known to congregate around platforms. This has been confirmed by snapshot surveys and diver observations. As yet, no long-term data exists to provide information on variations in shoal size and location over time, or on the behaviour of the shoal members. Whilst sonar surveys are the best technique for establishing shoal size and numbers of fish, only telemetry will allow the determination of the behaviour of an individual (how it makes use of the structure) and residence time. Their behaviour through a day in relation to the structure, tidal currents, light and food will provide indications of how the jacket may benefit the fish, for example the jacket may provide shelter from currents or create eddies that disorientate prey species. Residence time is a key factor in ascertaining the potential for the structure to provide benefit for the fish, if the fish do not spend a significant time close to the jacket then any possible positive effect will only be negligible to the overall success of that individual. Residence time would be a key factor in modelling the potential for jackets or clusters of jackets to produce benefit to the fish population.

The only certain way of determining individual behaviour and residence time is by marking that individual and tracking it. Conventional tagging would not be logistically feasible as the method relies on being sure of recapturing the individual, as does the sophisticated data logging tags used to gather long-term data on other species such as whales.

Telemetry allows animals to be followed in their natural environment, their location being given by signals from a tag on or in the body of the subject. In the sea, acoustic signals are commonly chosen because radio signals are rapidly attenuated in sea water. The best technique is acoustic telemetry either with constantly transmitting tags (pingers) or intermittent transponding tags. The latter requires a more complex tag and interrogator/receiver, but provides a longer lifetime for the tag.

Acoustic telemetry, in combination with sonar surveys, would be a powerful method, enabling the positive identification of schools of fish from the relative position of single tagged individuals.

6.5.7 Fisheries

6.5.7.1 Parameters

This section deals with how the various surveys and experiments, described above, will be combined to estimate various parameters associated with fish stock assessment and management.

Two main questions need to be answered in order to estimate if an artificial reef has a value within the fishery:

1. Does the reef function as a significant refuge for fish, especially juveniles?
2. Alternatively, can the reef be used so that it is an aid to commercial fishing?

This section will primarily deal with question 1. Whilst various associated parameters will need to be examined to give an overall view of the impact of a reef on the fishery, survey protocols will be mainly aimed at determining the standard fisheries equation, for the reef as described by Russell (1931) and Beverton and Holt (1957):

$$S_2 = S_1 + (A + G) - (M + C)$$

where S_1 and S_2 represent the total weight of fish at the beginning and end of a defined period, A is the recruitment, G is the growth, C is the fishing or capture mortality and M is the natural mortality. This is a simplification, but is an achievable first stage of reef assessment. To estimate even such apparently simple data from a multi-species fishery with open borders is notoriously difficult, so realistic aims must be adopted.

Answers to these questions should give a picture of which fish use the reef and to what extent they benefit from it, if at all. It must be stressed that fisheries science is inherently complex, with parameters that are highly variable, even chaotic. Within the proposed field programme, it should be possible to quantify certain key elements, e.g. growth rates on and off reef, and build-up a picture of the functioning of a reef.

The fisheries element of the programme will also include the following elements which are described in the previous paragraphs.

- *Quality*

A determination of what species are present, what is their size distribution and which are commercially valuable.

This will act as a control and allow an estimate of effectiveness of the reef at attracting and holding fish.

- *Quantity*

It will be of importance to know how many fish are present and in what densities. This can be done using an acoustic visualisation of shoals or mark-recapture techniques, though the later technique will not be logistically possible.

- *Growth*

Estimation of how fast the fish grow, and whether this differs from off-reef fish. Growth of fish caught on the reef will be compared with a control site without a reef, to indicate relative growth.

- *Natural mortality*

Determination of the age of the fish present, and whether they are any older, and therefore survive longer, than off reef fish, and also what level of intra and inter-specific predation there is. An indication of mortality can be gained from an examination of the stomach contents of the fish. This will indicate the size and types of fish eaten. Results will need to be combined with acoustic surveys and telemetry data to indicate the probability that the fish were eaten whilst on or off-reef. Further, survival relative to off reef areas may be possible to estimate from differences in the age structure of reef and ambient fish, as determined by sampling and otolith studies.

- *Location*

Determine where the various species are primarily located, and whether they are accessible to fishing gear. Acoustics and telemetry data will be used to describe the movement and position of the fish around and within a reef and thus indicate their accessibility to fishing gear. Ideally, if a reef is to be used for protection it would be hoped that the majority of juvenile fish remained within the reef. Whilst in a fishing enhancement reef, it would be hoped that there would be a large sphere of influence, allowing access to fishing gear.

- *Movement*

Determination of the length of time a fish spends on the reef, and at what times of the day and which season the fish are on the reef. Diurnal movements will need to be determined using acoustic surveys continuously through several daily cycles. Additionally video recordings from either a fixed camera or an ROV have been shown to be a useful means to indicate changes in fish abundance, and hence movement to and from the reef. Telemetry and repeated acoustic surveys can be used to show longer term movements of, in the former case, individual animals and in the latter case, shoals.

6.5.7.2 Summary of fisheries work required

In summary, in order to obtain data that will be required to both estimate the benefit of a reef to the fishery and to subsequently propose a suitable management plan, various parameters must be combined. Figure 6.1 summarises the fisheries work proposed.

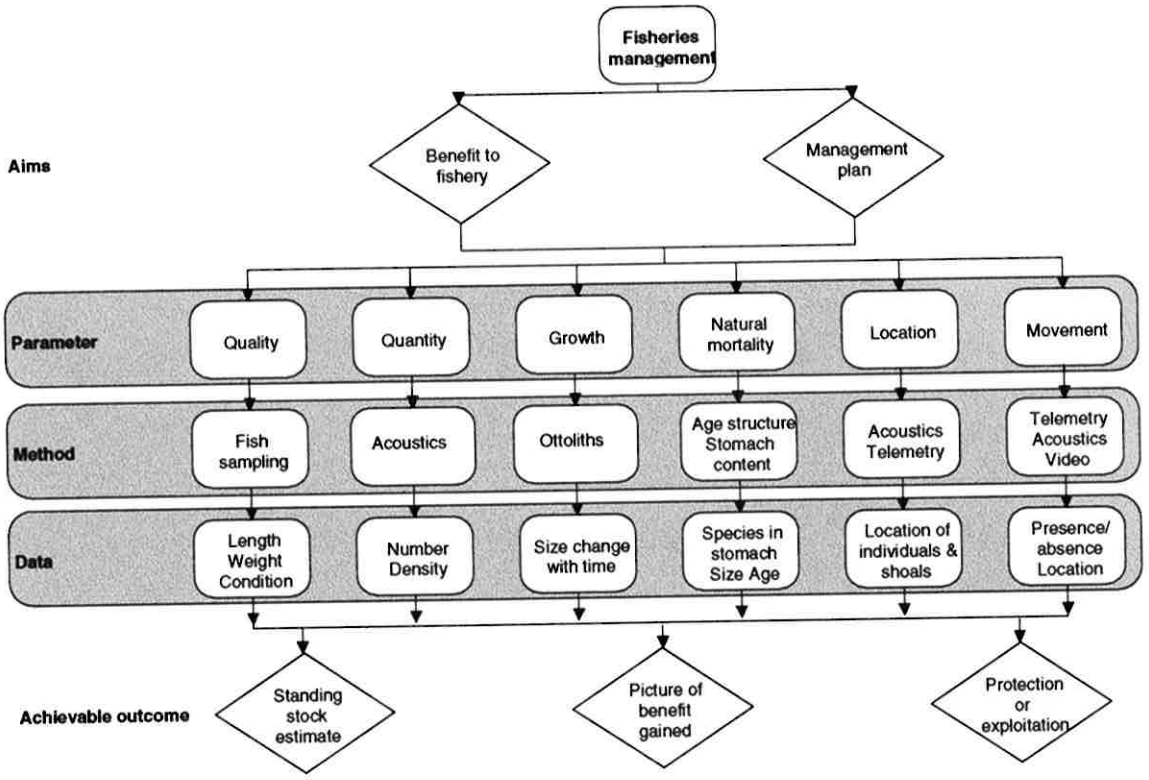

***Figure 6.1**: Summary of the fisheries work proposed and the achievable outcomes (Aabel et al., 1997).*

6.5.8 Commercial fishing

This section deals with methods associated with the commercial exploitation of the artificial reef fish stock. An artificial reef can be used either to protect fish from fishing pressure or as a fishing enhancement device. If a reef is to be used for fishing then the following attributes are required and need to be assessed:

- large standing stock, therefore dense shoals;
- fast replenishment after fishing;
- compliment of high market value species;
- fish of sufficient size to be caught by regulation gear;
- accessibility of gear to stocks.

Ideally, for a reef to be of value to fishermen, the catch per unit effort and the catch security will both be high. In other words, a fisherman who fishes the reef will achieve his target catch size in as short a time as possible and will have a high degree of confidence that he will not get a poor catch, respectively. In order for such an estimate to be made, the following 8 criteria will need to be assessed during this study:

1. standing stock size and shoal density;
2. location and movement of stocks;
3. species present;
4. size frequency distribution of the commercially valuable individuals;

5. stock replenishment time after fishing;
6. most suitable gear;
7. catch per unit effort:
8. sustainability of fishing.

The first four aspects have been described previously and so data will be available, assuming the other parts of this study have been conducted. The final four aspects then require further study.

6.6 Further work

6.6.1 Introduction

This section summarises the implementation of work proposed in this Report 6: *Monitoring*. A monitoring study for an established reef is proposed. The following actions are described:

1. The work to be conducted.
2. How and when this is to be done.
3. What type of results may be expected.
4. How these results assist the overall evaluation process.

6.6.2 Proposal for work to be conducted

Task 1 Baseline study prior to the reef implementation.

Task 2 Monitoring of the established reef.

6.6.3 Task 1: Baseline study prior to the reef implementation

6.6.3.1 How this is to be done

The monitoring summarises the practical work which will have to be performed during the baseline study. Some of the elements provide background information concerning food availability, shelter, presence of contaminants and hydrology. Other elements are directed towards commercial fishing and the socio-economic role of a reef.

6.6.3.2 When this is to be done

The study proposed will need to be conducted prior to reef implementation.

6.6.3.3 What type of results may be expected

Data that can be used to determine parameters that are vital to the assessment of several aspects, such as the success of the reef judged against various predefined success criteria, and the changing impacts of the reef, described in the Ekoreef report.

6.6.3.4 How these results assist the overall evaluation process

The results from this study will assist the overall evaluation process in terms of determining parameters for the assessment as to whether fishing on an artificial reef is likely to be feasible and an attractive economic proposition for fishermen. Alternatively they can be used to indicate how and how well a reef is functioning as a protected zone. The knowledge gained from a baseline study will help to assess whether the creation of artificial reefs in the North Sea is a viable disposal option, from an environment protection /fishing perspective.

6.6.4 Task 2: Monitoring of established reef(s)

6.6.4.1 How this is to be done

Once artificial reef(s) are established, based on the reef implantation plan described in Report 3 *Reef Configuration*, a monitoring program for the reef(s) needs to be conducted. The same parameters as described for the baseline study need to be monitored. Data will be compared both with the baseline (control) situation and between reefs. The monitoring program needs to include previous study methodologies conducted in other parts of the world, related to studies of the establishment and ecological developments at an artificial reef..

6.6.4.2 When this is to be done

The ongoing monitoring study can only start once the reef(s) are established and should continue for a period of at least 5 years, preferably somewhat longer.

6.6.4.3 What type of results may be expected

Results are expected to lead to an improved knowledge of the benefits from, and management of, platform reefs in the North Sea. An ongoing monitoring program may give better ideas for improvements, in terms of environment, management, benefits and economy.

6.6.4.4 How these results assist the overall evaluation process

In terms of overall evaluation process, the ongoing monitoring of established reefs may give clear evidence whether artificial reef(s) in the North Sea are a viable, beneficial option or not.

6.7 Conclusions

A study involving the elements described above should result in achievable data that can be used to determine parameters that are vital to the assessment as to whether fishing on an artificial reef is likely to be feasible and an attractive economic proposition for commercial fishermen. Without such knowledge, one of the main justifications for establishing a platform reef will remain unknown, and as such, the case for establishing the reef will be greatly weakened.

6.8 REFERENCES

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