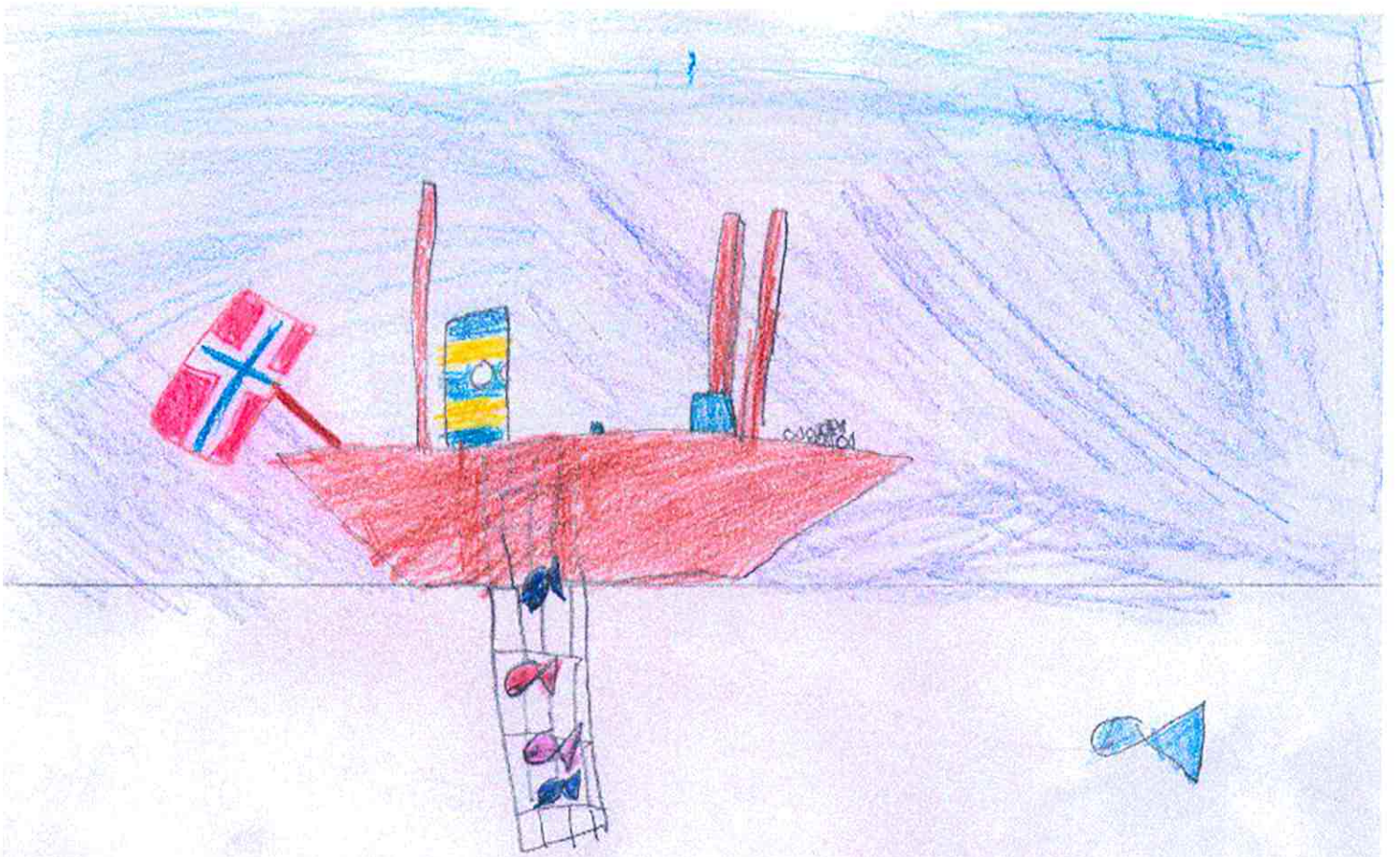
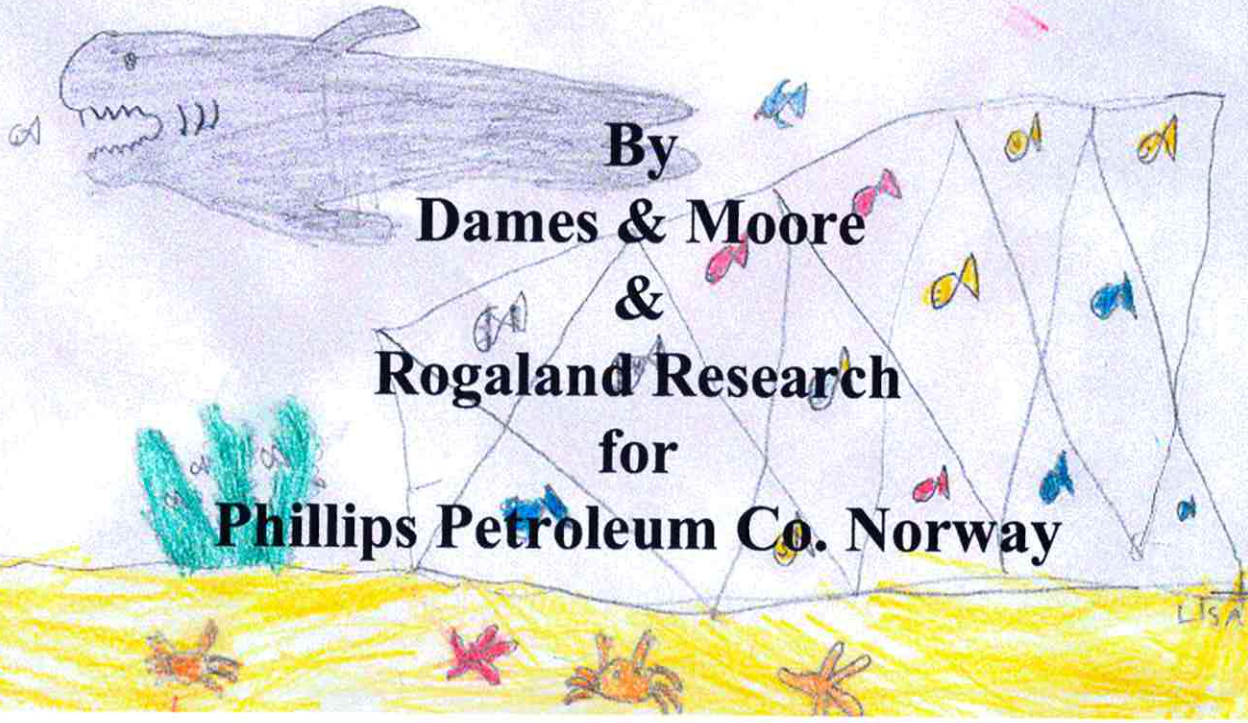


EKOREEF

Project 7: Alternative use



By

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EKOREEF - Sub-project 7: Alternative use

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Scope:
The Ekofisk Tank 2/4T, may remain *in situ* and form the nucleus of the reef complex. There is therefore potential for the multiple use of this structure. Such alternative uses would help both to justify leaving the structures on the field after cessation and could be a useful means to spark the imagination of the public. Alternative uses should ideally be in keeping with the ecological nature of the reef proposal, though not necessarily related to fish. A list of potential alternative uses fulfilling these criteria and a short description will be presented, and can form the basis of further discussions and future detailed planning focused on the uses with the most potential. The findings of this sub-report are to be summarised and simplified in a main report for the Ekoreef programme.

Key-words:
Ekofisk tank, alternative energy, artificial reef, Ekoreef, use, aquaculture, decommissioning.

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EKOREEF - Sub-project 7: Alternative use

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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 seventh and final project within the Ekoreef programme. A total of 7 main projects have been defined, 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 will be delivered through the Ekoreef Programme:

1. *Present status* - A recommendation will be given as to which areas (if any), around both 2/4 T and the Greater Ekofisk field, are 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 will be presented.
2. *Configuration* - Optimal design or designs of a potential Ekoreef will be prepared. These will incorporate recommendations for structures to be included in the reef, their configuration, location and the rationale used.
3. *Impacts* - Likely negative and positive impacts on the environment and associated socio-economics will be predicted.
4. *Management* - A plan for the management of the Ekoreef, including an assessment of its most beneficial uses will be prepared.
5. *Monitoring* - A plan for the future monitoring required around the Ekoreef will be proposed.
6. *Communications* - A plan for, and assistance with, the presentation of the Ekoreef concept to various groups will be prepared .
7. *Alternative use* - suggestions for the multiple, alternative use of Ekoreef components will be listed.

The reports from the projects will be collated into a concise final summary report.

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.
Demersal	Living at or near the bottom of the sea.
GIS	Geographical Information System.
Pelagic	Pertaining to the water column.
Reference point	Fixed position of a platform which is not to be moved, about which the rest of the reef will be located.
THC	Total hydrocarbons
Economic lifetime	Time to end of production, i.e. to the closing down date.
Expected lifetime	Time to deterioration and collapse of structures.
Artificial reef core	Location of the central reference point for a reef.
Artificial reef unit	Reef comprising three or more components in close proximity.

7. EKOREEF PROJECT 7: ALTERNATIVE USE

7.1 Summary

Alternative use - suggestions for the multiple, alternative use of the Ekofisk Tank, 2/4T, are listed. The main goals for sub-project 7 are:

- Identify which realistic alternative uses exist.
- Briefly describe each alternative.

There are five main alternative uses for the Tank:

1. Location for the development of alternative energy sources.
2. Station for research, harvesting and processing of marine resources.
3. Centre for infrastructure development.
4. Reuse in the petroleum industry.
5. Recreational facility.

The description of each major alternatives indicates that some of the alternatives listed may be suitable for implementation, and some alternatives imply high cost, high risk and may not be prioritised by PPCoN. The abandonment of the Tank, may have an environmental impact on the surrounding ecology.

The following main conclusions could be drawn:

- The Tank could serve as an alternative energy research and development centre. Power may be generated from the use of geothermal energy, wind and wave-forces or tidal flows. Another option is to use the Tank to develop a heat-exchange pump system, or use it as a refuse processing facility.
- The Tank may serve as a centre for research, harvest and processing of marine resources, such as wild fish, ranched fish, fish-farmed fish, or shellfish.
- The Tank has a convenient central location, and could be an important communication and infrastructure component. It may also serve as a distinct navigation point for ocean-vessels or aircraft.
- It may be possible to re-inject waste from Tank into the reservoirs, e.g. CO_2 gas, drill cuttings or other non-desirable waste products.
- The Tank could serve as emergency and education facilities. Rescue training and development and professional diving training may be considered.

7.2 Introduction

7.2.1 Background and aims

The elements of the planned Ekoreef are of significant size. Additionally, the Ekofisk Tank is assumed to be abandoned in place, and may form a nucleus of the reef complex, extending above the water surface. There is therefore potential for the multiple use of these structures or the Tank alone. Such alternative uses would help both to justify leaving the structures on the field after cessation and could be a useful means to spark the imagination of the public.

From Sub-project 2, *Configuration* the assumption that the Tank will be abandoned and used as an artificial reef component are made. Based on this, the alternatives listed are focused on the use of the Tank in addition to it being used as a reef component. The aims for this sub-project 7 are therefore to:

- Identify which realistic alternatives exist.
- Briefly describe of each alternative

There are five main alternatives listed, that are focused on the use of the Tank in addition to it being used as a reef component.:

1. Location for the development of alternative energy sources.
2. Station for research, harvesting and processing of marine resources.
3. Centre for infrastructure development.
4. Reuse in the petroleum industry.
5. Recreational facility.

A short description of each major alternative will be presented in the next section.

7.3 Identification of alternatives

Alternative uses should be in keeping with the ecological nature of the reef proposal. A list of potential alternative uses fulfilling these criteria and a short description will be presented in the following sections. Alternative uses can be divided into either:

- leaving the Tank *in situ*;
- removal of the Tank.

The alternatives for leaving *in situ* are based on the assumption that the Tank is abandoned and all the other structures are used as reef components, whether they are toppled in place or placed in clustered reefs.

The alternatives for the removal of the Tank are outside the scope of this project. This sub-project does not include a description of the alternatives for removal of Tank. Alternatives are however identified but not described.

7.3.1 Alternative uses for leaving the Tank in situ

Alternative uses for leaving the Ekofisk Tank *in situ* may have several options. The main goal is to present realistic alternatives.

Alternative for leaving *in situ* are as follows:

1. Location for the development of alternative energy sources:

- conversion to a geothermal energy, power station;
- conversion to wave energy, power station;
- conversion to wind energy, power station;
- conversion of energy from tidal currents;
- heat exchange pump;
- processing facilities for disposal of refuse, incineration.

2. Station for research, harvesting and processing of marine resources:

- *in situ* harvest of ocean resources, i.e. mariculture;
- ocean ranching;
- aquaculture;
- fish processing facilities;
- marine research station;
- artificial reef research centre.

3. Centre for infrastructure development:

- infrastructure component;
- transport of non-petroleum products;
- military facility.

4. Reuse in the petroleum industry

- continued use in the petroleum sector;
- re-injection of CO_2 and/or drill cuttings;
- centre for off-shore rescue - training and education;
- professional offshore diving training centre.

5. Recreational facilities

- hotel accommodation;
- sport facilities;
- conference facilities;
- sports-fishing;

One additional option is, abandonment and maintain *in situ* (either preserving the integrity of the structure (e.g. for the purpose of deferment), or leaving the structure to gradually disintegrate under the influence of natural processes.

There are several alternatives to consider. The seriousness with which they may be considered is primarily dependant on economic considerations. Risk and safety assessments of each alternative must also have a high priority.

7.3.2 Alternative options for removal of the Tank

Removal of the Tank or platforms may imply a higher cost for PPCoN. This may imply less responsibility and legal requirements if the Tank or platform is reused, dismantled (recycled) or deep sea dumped. Removal of a platforms is a technical challenge, because of the weight, size and exposed location. Technology for the removal of these structures (sub-project 2, *Configuration*) is however available.

The following realistic removal alternatives exist:

- offshore disposal (deep sea site);
- onshore disposal (dismantling), i.e. removal of the redundant structure, including partial or total removal of the whole part of the structure. Onshore recycling or disposal of the whole platform;
- re-use in the offshore oil and gas industry.

A description of each decommissioning alternative is, as mentioned earlier, outside the scope of this sub-project.

7.4 Description of each alternative

Five main alternative uses for leaving the Ekofisk Tank in situ are proposed and listed above. The following is a more detailed description of each of these.

7.4.1 Location for the development of alternative energy sources

The energy consumption in western society has increased substantially the last decade. There may therefore be a need for alternative thinking in terms of power supply in the future (Rogers & Mayhew, 1980). The Tank has a potential to be used as either a power station by using geothermal, tidal, wave or wind energy.

Geothermal energy can be used to heat water and drive a steam turbine. Power can also be generated from a windmill or wave generator. Another, and existing alternative is to use excess oil or gas, and convert these energy sources to heat. Useable power can be generated from this heat, by installing steam and/or gas turbines. The energy source may come from existing production at Ekofisk 2. The economical feasibility of these options does however need to be addressed.

Using tides in the area to create an alternative energy source as has potential. Tidal currents are an energetic feature in the North Sea, stirring the entire water column in most of the southern North Sea (OSPARCOM, 1993), so it may be possible to generate power by this method. It should however, be noted that in the North Sea there are amphidromic points, around which there is no tidal variation. One point is west of Jylland (Denmark), and one is west of Rogaland (Egersund) (Breen, 1980)

A heat exchange pump may be used at the Tank as a source of energy. The North Sea ocean can be the medium from which heat may be extracted. The need for this type of energy source may be limited, since there are already other options at the site.

At the Greater Ekofisk field, and in the North Sea in general, there are several production facilities, and hence the waste generation from both oil and gas production and the human work force may be useful as a new alternative power source. Incineration of the refuse can create heat, which could be used in a steam turbine. There may also be potential for recycling several products for resale. Processing facilities for dealing with waste may also include the ability to re-inject CO_2 or drill cuttings.

These options may need some more development to become feasible and economical alternatives. The Tank may therefore become a centre for research and development.

7.4.2 Station for research, harvesting and processing of marine resources

The Tank may also serve as a centre for the harvest of marine resources. This could include the harvest of resources such as: wild fish, fish-farmed fish, shellfish, crawfish or ranched fish.

Mariculture, (the farming of marine organisms) may be possible in the upper layers of the water column. The sea-bed at he Tank is contaminated, but production of oysters, shellfish or sea-plants is a possible option if they are held above the bottom. Such off-bottom techniques, including the hanging culture of shellfish is currently widely practised Another option is to «seed» different species like lobster or crab, the depth at Ekofisk is somewhat greater than the natural range for lobsters. The weather and rough sea, may imply high expenses to create an efficient production, and hence limit this option.

Ocean ranching of salmon, cod etc. may also be considered. This is a concept in which juvenile fish are released into an area in the hope that they may be recaptured after they have grown to a marketable size. The Tank itself could serve as a hatchery for the production of eggs and juveniles. The method would focus on the need to restore some fish species, in addition to the creation of a potential new industry, "wild fish farming".

A problem with this method would be ensuring that the fish remained in the vicinity of the Tank. In an attempt to solve this problem and even to attract a greater number of wild fish to the area, the NFO Gruppen AS from Leknes in Norway (NFO, 1997), have developed in detail an "active fish house" system, which they planned for use around the Brent Spar as an artificial reef. Their system includes the feeding of, primarily cod and halibut, using waste fish off-cuts from the capture and culture fish processing industries.

Another and further step from the ranching is aquaculture. Farmed fish can be produced in large net cages. The knowledge and technology for large offshore cage fish farming exists and is practised in many salmon growing countries. The challenge in this regard could be the need to hinder escaped fish, because of severe weather, the danger of diseases to natural stock in the area, the expenses with transport and shipping of fish food, and delivery of the harvested product.

It is possible that the Tank could be used as a processing facility for products from capture fishing, mariculture, ranching and aquaculture. The Tank would then be a natural nucleus where all these products from the region as a whole may be processed. The waste products from this processing facility can then be used to produce farmed fish food.

In addition to the production of marine resources, the Tank could be used as a marine research station. Assuming that artificial reefs are created at the Ekofisk field, there will certainly be a need for monitoring and research on these reefs. A fixed structure extending out of the water would be a most useful facility for intermittent visits by researchers and for the attachment of long-term monitoring equipment.

7.4.3 Center for infrastructure development

Several platforms in the area will be decommissioned in the future. This implies that they will become unsuitable as part of an infrastructure component (*in situ* toppled or removed). The Tank could therefore be developed to an important communication and infrastructure component, since it is assumed to be abandoned.

Transport, storage and delivery of supplies, human or petroleum products may be considered. Also transport of non-petroleum products such as recycled material, processed marine products from fish or waste products from the oil-industry are other options, as mentioned above.

The Tank must be marked and maintained properly. If the Tank is developed as an infrastructure component, it may also serve as a distinct navigation point for ocean-vessels or air crafts. A use for military/navy purposes, in regard to navigation and infrastructure is also an option.

7.4.4 Reuse in petroleum industry

The Tank has been in production for over 20 years. Continued use of the Tank in the petroleum industry depends on the options PPCoN decides upon. Alternative use of the Tank may be to use it as a base to re-inject waste, both CO_2 gases, drill cuttings or other non-desirable waste products.

Over the past years, PPCoN and the offshore industry have focused on health and safety in the production. Rescue training can be implemented, together with more safety issues on the platforms. The Tank could serve as emergency rescue centre, in addition to education facilities for rescue training and development, and professional diving training.

7.4.5 Recreational facilities

These following alternatives can be suggested: hotel accommodation, sport facilities, conference facilities and sports-fishing. They can not be considered seriously, until an evaluation indicates that there is a market for this use and that the economics are feasible, thus justifying its implementation.

7.5 Considerations for the Ekofisk Tank

The Ekofisk Tank is assumed (in this Ekoreef project) to be abandoned, and potentially used as a nucleus for an artificial reef. I addition to being part of a reef, the Tank left *in situ* can be used as the site for one of the alternatives listed and described above. Leaving the Tank *in situ*, may however have an environmental impact on the ecological system. This is discussed in Sub-project 3: *Environmental impacts*.

In this section, some few consideration are presented, since the Tank itself is the main concern if it used for one or several alternatives listed above. From the many effects relating to the abandonment of the Tank, this section focuses on two direct environmental effects:

- The physical effects of the structure on the seabed.
- The leaching of the contaminants in drill cuttings.

The consequences of the physical presence of the Tank on the seabed are two-fold:

- It is likely to act as a substrate for deep sea organisms and become colonised over time by various epifauna. Initial colonisation may however be retarded by the effect of contaminants and activity associated with the Tank on the colonising organisms.
- It should not currently interfere with other resource users such as existing production or commercial fisheries.

Assuming that the previous contamination degrades and the existing production (Ekofisk 2) has improved to a better and "cleaner" production level, the slow leaching of the remaining contaminants from drill cuttings into the water column and sediment could still give rise to

local elevations in heavy metals and hydrocarbon concentrations in the water column and sediments. This may be toxic to organisms and influence local population distributions.

Abandonment of the structure may require that it is maintained to ensure structural integrity in order to prevent the Tank and reef components becoming a hazard to fishing and other marine interests. Both the maintenance requirements and the hazards to other marine interests represent long term liabilities for the owner of the platform. Sea-bed subsidence in the Ekofisk area is likely to adversely effect the stability of the Tank and increase the potential cost of maintenance. As the Tank sinks, wave intrusion will increase, increasing the breakdown of facilities and making the structure less safe for personnel onboard.

The physical presence of the structure would constitute a long term risk to shipping and navigation with associated liabilities. Structural failure of the installation could result in the production of breakaway debris and associated risks to shipping and impact on the sea bed environment. Rupture of pipes and vessels could lead to release of contaminants to the environment.

In general, an extensive use of the Tank, needs to be defined, ownership and legal aspects considered, and risk assessments conducted. This is however outside the scope of this preliminary discussion document.

7.6 Conclusions

The potential for alternative uses of the Tank, in addition to using it as an artificial reef component exists. Several realistic options are listed, though only few are worth further considerations and even implementation.

The main limiting factors for the implementation are the economic, risk and safety considerations. Evaluation of these parameters is however outside the scope of this work, and needs to be investigated in more detail.

Five main alternative uses for the Ekofisk Tank were identified:

1. The Tank could serve as an alternative energy research and development centre. Power may be generated from the use of geothermal energy, wind, tidal or wave forces. The Tank may also be used to develop a heat-exchange pump or as a refuse processing facility.
2. The creation of alternative energy sources on the Tank, imply further consideration of how to transfer this energy to other production sites or urban areas, since there is limited demand for power at Ekofisk 2.
3. The Tank may serve as a centre for research, harvesting and processing of marine resources such as: wild fish, ranched fish, fish-farmed fish or shellfish. Biological production at the Tank has potential, assuming the organisms are maintained off the bottom to avoid the negative effects of the contamination around the Tank. The weather and rough sea, may increase the expense of biological production, and hence limit the mariculture and aquaculture option.
4. The Tank has a convenient central location, and could be an important communication and infrastructure component. It may also serve as a distinct navigation point for ocean-vessels or aircraft.
5. The Tank may be also be used as a base to re-inject waste, such as CO_2 gases, drill cuttings or other non-desirable waste products.

Additionally, the following less likely alternatives may be possible.

- The Tank could serve as emergency and education facilities. Rescue training and development and professional diving training may be further uses.
- Its use as recreational facilities may not be realistic, unless proved feasible by a market and economic evaluation.

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