



LIFE Project Number
LIFE06 NAT/DK/000159

TECHNICAL FINAL REPORT
Covering the project activities from 01.08.2006 to 01.04.2013

Reporting Date
01/07/2013

LIFE PROJECT NAME
Rebuilding of Marine Cavernous Boulder Reefs in Kattegat

Data Project

Project location	Denmark
Project start date:	01/08/2006
Project end date:	01/04/2013
Total Project duration (in months)	80 months
Total budget	€ 4.808.398
EC contribution:	€ 2.364.199
(%) of total costs	49.17 %
(%) of eligible costs	49.17 %

Data Beneficiary

Name Beneficiary	Danish Nature Agency
Contact person	Mr Jakob Harrekilde Jensen
Postal address	Haraldsgade 53, DK, 2100 København Ø
Visit address	Haraldsgade 53, DK, 2100 København Ø
Telephone	+45 72 54 30 00, direct +45 72 54 21 60
Fax:	+45 39 27 98 99
E-mail	nst@nst.dk or har@nst.dk
Project Website	www.blureef.dk

1. LIST OF CONTENTS AND ANNEXES

1.	List of Contents and Annexes	2
2.	List (i) key-words and (ii) abbreviations.....	4
2.1.	Key-words	4
2.2.	Abbreviations	4
3.	Executive Summary	5
4.	Introduction.....	7
4.1.	Background, problem and objectives	7
4.2.	Overall and specific objectives.....	7
4.3.	The socioeconomic context of the project.....	7
4.4.	Expected results.....	8
5.	LIFE-project framework	9
5.1.	Overview of project actions	9
5.2.	Project organisation.....	9
5.3.	Project modifications.....	10
6.	Progress, Results	12
6.1.	Preparatory actions	12
6.1.1.	Action A.1: Geological Design Data	12
6.1.2.	Action A.2: Hydrological Design Data.....	12
6.1.3.	Action A3: Impact on sediment transport.....	13
6.1.4.	Action A.4: Reef design and call for tenders	14
6.2.	Non-recurring biotope management.....	15
6.2.1.	Construction of cavernous reefs at Læsø Trindel	15
6.3.	Public awareness and dissemination of results.....	18
6.3.1.	Action E.1: Mounting of information boards.....	18
6.3.2.	Action E.2: Production of a Layman´s report.....	18

6.3.3.	Action E.3: Project Internet Web Site.....	19
6.3.4.	Action E.4: Video on marine boulder reef restoration.....	19
6.3.5.	Action E.5: Information to the local communities and the public	20
6.3.6.	Action E.6: International Seminar on Marine Nature Restoration.....	21
6.3.7.	Action E.7: Under water trail.....	23
6.4.	Overall project operation and monitoring	24
6.4.1.	Action F.1: Project management and co-ordination	24
6.4.2.	Action F.2: Biological Monitoring Programme	25
6.4.3.	Action F.3: Post bathymetry and stability of reef structures.....	27
6.4.4.	Action F.4: After-LIFE Conservation Plan.....	28
7.	Evaluation and Conclusions.....	29
7.1.	The process.....	29
7.2.	The project management	29
7.3.	Success and failures.....	30
7.4.	Comparison against the project-objectives.....	31
7.5.	Environmental benefits, policy and legislation implications	32
7.6.	Innovation, demonstration value	33
7.7.	Socio-economic effects	33
7.8.	Long term indicators of the project success	33
8.	Comments on Financial Report.....	35
9.	Annexes.....	37

2. LIST (I) KEY-WORDS AND (II) ABBREVIATIONS

2.1. Key-words

Offshore cavernous boulder reefs, nature restoration, Natura 2000, 1170 Reef habitat, Læsø Trindel

2.2. Abbreviations

ASEP: Agency of Spatial and Environmental Planning

AU: The University of Aarhus

DIFR: Danish Institute for Fisheries Research

DFNA: Danish Forest and Nature Agency

DNA: Danish Nature Agency

DTU Aqua: National Institute of Aquatic Resources, Technical University of Denmark

NERI National Environmental Research Institute

3. EXECUTIVE SUMMARY

The objective is to restore and stabilize the structure and function of a cavernous boulder reefs at the Natura 2000 site Læsø Trindel and Tønneberg Banke, and to increase awareness among environmental managers, policymakers and the broader public on marine nature restoration and management issues.

The key deliverables and outputs are:

- Preliminary investigations to analyse project feasibility and to elaborate reef design
- Rebuilding of 5 ha of cavernous boulder reefs using about 100.000 tons of boulders
- Documentary video and other dissemination activities such as website and leaflet
- International symposium on “Marine Nature Restoration in Northern Europe”
- “Codes of conduct” with recommendations and guidelines to restore natural stone reefs
- Biological Monitoring Programme of the colonization of the new reef structure

Offshore cavernous boulder reefs in shallow waters have a high biodiversity and are a rare and biological important subtype of the 1170 Reef habitat at the national and European level.

The DNA has the overall responsibility for the implementation with the partners AU and DTU Aqua responsible for the monitoring programme. A Steering Group and an Advisory Board have been set up to secure co-ordination and involvement of stakeholders.

The preparatory actions have involved geological survey to secure a stable and solid ground for the reef construction, and modelling of hydrological design data to evaluate sediment transport and to elaborate a reef design.

A project area has been marked and 100.712 tons of boulders from a Norwegian quarry have been loaded and transported on a barge to Læsø Trindel. Excavators with geographical positioning system have been used to unload the boulders. The position of some of the boulders have been adjusted using a vessel formerly used for boulder extraction.

Information boards, project web site and documentary video have been produced in order to disseminate the project. Three public meetings have been held at the island of Læsø to inform about the project and to discuss the different activities. An international symposium was held with about 65 participants from 8 different European countries to share experiences. A “codes of conduct” has been elaborated with recommendations and guidelines to restore natural stone reefs.

A biological monitoring programme has been carried out based on a “before-after” approach showing that there has been an overall increase in biomass of 6-8 fold and an increase in abundance of individual fauna species of 4-6 fold. Changes in the fish community structure were also evident. Larger juvenile gadoids cod and saithe increased with a factor 3-6 and it was notable that the higher abundance of cod mainly was observed in the shallow part where the cavernous reef structure had been re-established. The ecological benefit is expected to increase further in the years to come.

Post bathymetry has shown that the new reef structures are stable. Located in a Natura 2000-site the restored reef will be part of the Natura 2000 conservation plans, and the project will be

disseminated through the project web site, where yachtmen can get information about safety precautions and divers about the deployment of diver buoy.

The preliminary investigations and the construction of the cavernous reefs have been implemented successfully. The first tender was too expensive and a revised design had to be carried out. As a result the rebuilding of the reef was delayed one year and the project was extended with one year to allow for a colonization period of flora and fauna. The international symposium, the documentary video and the elaboration of a “codes of conduct” have been very successful and have created a greater awareness of marine nature restoration. An underwater trail was replaced by a leaflet for divers and other visitors due to strong wind and currents..

The three objectives of the project have all been obtained. The cost of construction is considered to be very high and could be reduced if the restoration is coordinated with infrastructure projects like windmills, tunnels and roads, where natural stones have to be removed. An important lesson learnt is that safety for yachtmen and others cannot be underestimated and it is essential to not only update the chart but to deploy additional marking and to about safety precautions.

The ecological benefit of the restoration project has been considerable. The “codes of conduct” contains valuable experiences and recommendations for others who want to restore natural stone reefs in Denmark and Northern Europe.

Local fishermen is sceptical about the benefit of the project and the value of the reef as a donor-area. Fishing is no longer prohibited at the restored reef. Trawling is however as a general protection in all Natura 2000 sites, planned to be prohibited at the reef and within a buffer zone of 240 m.

The project is considered to be a very innovative project with a high demonstration value. It has come up with solutions to deal with preliminary investigations and the challenge of getting a large amount of boulders unloaded at the sea bottom under difficult weather conditions. It shows that marine nature restoration can contribute to restore marine nature values.

4. INTRODUCTION

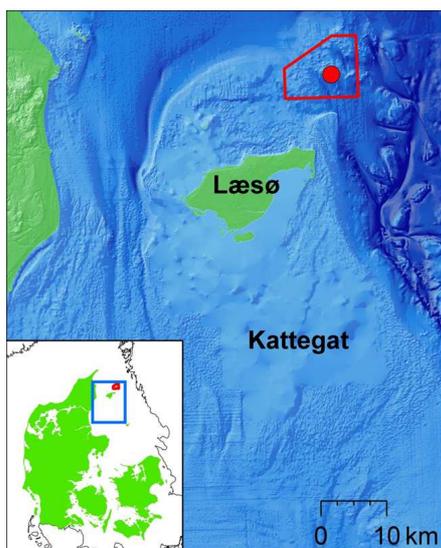
4.1. Background, problem and objectives

Offshore cavernous boulder reefs in shallow waters have a high biodiversity and are a rare and biological important subtype of the 1170 Reef habitat at the national and European level. On a national level the cavernous boulder reefs have through decades been extensively exploited for constructing of sea defences and harbour jetties. A cautious estimate is that at least 34 km² of boulders from predominantly shallow cavernous reefs have been excavated from Danish waters or close to 100% of the area of this habitat with cavernous structures.

A site of community importance has been selected in Kattegat to be a sanctuary for donor populations and function as a crucial stepping stone within a blue corridor linking sites within the NATURA 2000 network. The restored site is believed to become a significant contribution to maintain 1170 Reef depending populations in Denmark.

4.2. Overall and specific objectives

The overall objective is to restore and maintain a favourable conservation status of the offshore 1170 reef habitat at Læsø Trindel and Tønneberg Banke, Natura 2000 Site no DK00VA249. The Natura 2000 habitat site at Læsø Trindel is partly designed because of its boulder reefs.



Map of the Natura 2000 Site Læsø Trindel and Tønneberg Banke (red figure) and the project area (red spot).

The objective will be obtained by:

- Restoration of the structure and function of the cavernous elements of the shallow offshore boulder reefs.
- Stabilization of the top of the existing boulder reef.
- Increased awareness among environmental managers, policymakers and the broader public on marine nature restoration, conservation and management issues.

4.3. The socioeconomic context of the project

The island of Læsø is a small isolated island with only about 2000 inhabitants. Major incomes come from fishing and tourists. It is believed that the new reef will attract tourists and divers. Moreover the new reef will probably be able to deliver a spin off of commercial species such as cod and lobsters to be cashed.

4.4. Expected results

The project includes restoration of 6 ha of offshore shallow cavernous boulder reef habitat with a total volume of about 56.000 m³. This includes stabilisation of 5.5 ha at the top of the boulder reef or close to 100% of the deteriorated reef area. The restored site is believed to obtain favourable conservation status and become a significant contribution to maintain 1170 reef depending populations in Denmark.

To document the effect of the restored reef structures a monitoring programme has been set up. The monitoring programme is based on a 'Before – After' approach and will deliver important information about the success of the project. Such information will be useful for future marine restoration projects.

Moreover an international seminar will be held. At the seminar results of the project will be discussed and recommendation for future marine nature restoration will be prepared.

5. LIFE-PROJECT FRAMEWORK

5.1. Overview of project actions

The project involves A. Preparatory Actions, C. Non-recurring Biotope Management, E. Public awareness and dissemination of information and F. Overall Project Management. The table below gives an overview of the actions of the project.

Action	Description of action
A1	Investigation of sediment
A2	Modelling hydrological data
A3	Modelling sediment transport
A4	Reef design and call for tender
C1	Construction of cavernous reef
E1	Information boards
E2	Layman's report
E3	Web site
E4	Video
E5	Information, local meetings
E6	Seminar
E7	Under water trail
F1	Project management
F2	Biological monitoring programme
F3	Post Bathymetry and stability
F4	After-LIFE Conservation plan

Overview of actions

5.2. Project organisation

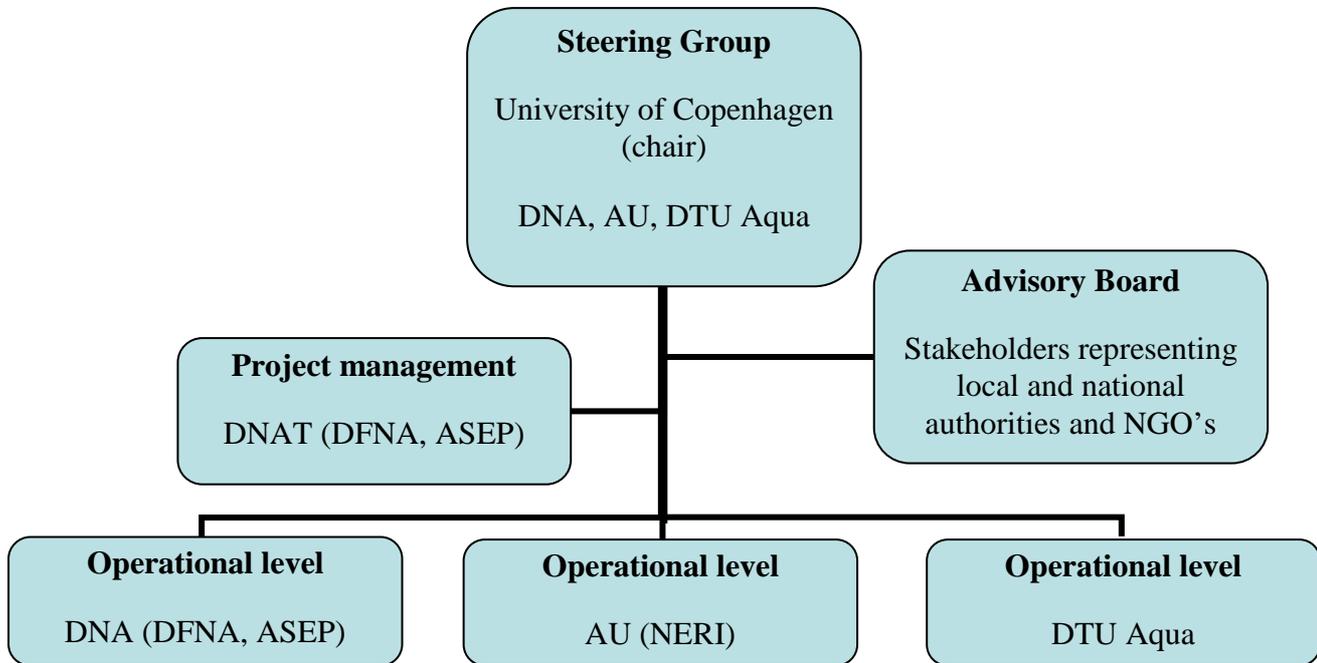
The main function and responsibility of the Steering Group is to ensure that milestones are reached and to discuss the progress of the project and provide guidance to the project manager. Katherine Richardson Christensen has been chosen as chairman. She is a professor in marine biology employed at the University of Copenhagen. Beside the chairman the partners of the project is part of the Steering Group.

The main function of the Advisory Board is to advise the partnerships and the Steering Group on stakeholder views. The Advisory Board will once the project has started be set down based on major stakeholders, who have expressed an interest in participating.

The DNA (former DNFA and ASEP) has the overall responsibility for the implementation of the project and has as beneficiary the responsibility for project management in relation to The European Commission.

The partners AU (former NERI) and DTU Aqua (former DIFR) have as main responsibility to describe the monitoring programme and subsequently carry it through. Moreover they participate in meetings with the public and they will participate in planning and completion of the seminar to be held.

The change in project organisation is described in Section 5.3.



5.3. Project modifications

Project organisation

From 1 January 2007 the partner NERI merged with AU with no change in rights and obligation and as a result NERI is withdrawn and replaced by the UA. From the same time, the partner DIFR merged with DTU with no change in rights and obligations and as a result DIFR is withdrawn and replaced by DTU. The modification was approved by the Commission 02 July 2007 (Supplementary Agreement No 1).

The Danish Ministry of Environment implemented a new organization with effect from October 1 2007. The professional competence on marine aspects, including the former DNFA staff involved in the Blue Reef project management, was placed in a new agency (ASEP). As a result ASEP was included as a new partner with responsibility for the majority of the project management. The modification was approved by the Commission 20 February 2008 (Supplementary Agreement No 2).

DNFA and AESP merged to form DNA as from 1st January 2011. As a result DNA became beneficiary of the grant agreement instead of DNFA and took over the tasks of ASEP. The modification was approved by the Commission 6 June 2011 (Supplementary Agreement No 3).

Change of reef design

DNFA was in summer 2007 forced to cancel the tenders for the reef constructions according to the rules of public procurement as the two bids exceeded the economic threshold level. A revised design with a reduced amount of quarry stone and area but still fulfilling the objectives of the Blue Reef restoration project was elaborated in autumn 2007. The modification was approved by the Commission 20 February 2008 (Supplementary Agreement No 2).

Extension of project period

The deployment of large boulders was delayed from autumn 2007 to autumn 2008. The monitoring in 2010 demonstrated that the colonization on the new reef was on-going but the macro algal vegetation was still dominated by opportunistic species like thread forming leaf structures. As a result the project was extended with 12 months to allow for a colonization period of 3 ½ year before the final monitoring. The modification was approved by the Commission 6 June 2011 (Supplementary Agreement No 3).

6. PROGRESS, RESULTS

6.1. Preparatory actions

6.1.1. Action A.1: Geological Design Data

The engineer Arccon A/S has formulated detailed specifications for the survey and the contractor Jysk Geoteknik A/S has carried out the field survey as well as the following sediment analysis.

A survey of the sub-surface properties of the project area and a detailed description of the sediment distribution of the project area has been made. The results are based on sediment samples (digging profiles) from the surface and sub-surface of the seabed at the project area combined with a seismic survey. The profiles and seismic survey show sediment properties with a top-layer of sand/gravel of various thicknesses up to approximately 4 meters on a deeper sub-layer of clay. The seabed was estimated as stable and a solid ground for the reef construction. The result was used in action A.4 Reef Design for identifying the optimal areas for restoration of the reef.

The report “Bundundersøgelse” (Danish only) describes the methodology, results and conclusions and is available on the project web site, www.blureef.dk.

Action A.1 was started 1 August.2006 (foreseen 1 August 2006) and ended 8 November 2006 (foreseen 1 November 2006).

The cost of Action A.1 amounts to 44.445 Euro.

	<i>Budget</i>	<i>Incurred cost</i>	<i>Discrepancy</i>	<i>%</i>
Action A.1	45.087	44.445	-642	-1,4

6.1.2. Action A.2: Hydrological Design Data

The Danish Meteorological Office has been contracted to advise in choosing an external contractor and making a contract. The contractor DHI-Water-Environment-Health has carried out the numerical studies of hydrodynamic conditions at Læsø Trindel including the local marine region with Kattegat and inner Danish waters.

The studies included numerical modelling of wave, current and sea level conditions. The numerical modelling of the hydrodynamics and the wave conditions provided input to the assessment of the sediment transport and stability of the existing situation as well as the situation with the new reefs.

The wave model has been calibrated and validated against existing data for the regions weather conditions. The model meets the requirements of the project and is concluded to work well. The model has been used to simulate e.g. different wave heights at different weather conditions on different locations on Læsø Trindel.

The report “Blue Reef Hydrographic Design Data” describes the model, input parameters and results and is available on the project web site, www.blureef.dk.

Action A.2 was started 10 October 2006 (foreseen August 2006) and ended 23 May 2007 (expected 1 May 2007).

Action A.2 and Action A.3 have been carried in close connection and with the same contractor. The total cost of Action A.2 and A.3 amounts to 119.785Euro.

	<i>Budget</i>	<i>Incurred cost</i>	<i>Discrepancy</i>	<i>%</i>
Action A.2	64.603			
Action A.3	55.182			
<i>Action A.2+A.3</i>	<i>119.785</i>	<i>109.200</i>	<i>-10.585</i>	<i>-8,8</i>

6.1.3. Action A3: Impact on sediment transport

Danish Meteorological Office has been contracted to advise the DFNA in choosing an external contractor and making a contract. The contractor DHI has carried out the numerical studies of the impact of sediment transport at Læsø Trindel.

The studies included numerical modelling of wave, current and sea level conditions. The sediment transport studies include numerical modelling of the existing conditions as set up in Action A2. The numerical modelling of sediment transport conditions includes simulations of the existing situation and of the situation after the reconstruction of the reef. The study is based on modelling of weather conditions as storm events and calm weather situations.

The numerical modelling of the sediment transport in the area of Læsø Trindel has taken into consideration the new reefs designed in Action A.4. The sediment transports condition before and after the new reefs have been compared to evaluate the expected impact of the reefs. The simulations shows that during calm weather situations the new reef structures of a scale as designed on Læsø Trindel will have no discernable impact on the sediment. Changes in current speed above 0.1 m/s and changes in the significant wave heights above 0.1 m cannot be observed further than 600 m from the new reef structures. These changes are observed in the simulation during the peak of the strongest storm event modelled. No considerable changes in the simulated sediment transport rates and erosion and deposition field are observed further than 300 m from the new reef structures.

Annual erosion and deposition rates of about 20-30 cm/year are estimated locally around the western and central reefs. Local sedimentation can take place in the lee side of the reefs depending on the flow field. The largest erosion and deposition rates will take place in the first years after the construction of the new reefs. These will gradually decrease until an equilibrium situation is reached. The sedimentation transport rates as well as the erosion/deposition rates are relatively small hence no significant reduction in the functionality of the new reefs is expected.

The modelling shows no indication that sediment transport condition in the area of the habitat 1180 Submarine structures made by leaking gases (approx. 1200-2000 m north-east of the restoration area) can be influenced as a consequence of the final reef design. The distance between Østerby Harbour on Læsø and Læsø Trindel is approx. 12 km and this distance is much beyond the area of influence of the reef design. The navigational access to the port will hence be unaffected by the new structure in the restoration area.

The report “Blue Reef Impact of Sediment Transport” describes the methodology, results and conclusions and is available on the project web site, www.blureef.dk.

Action A.3 was started 10 October 2006 (foreseen Autumn 2006) and ended 17 August 2007 (expected 15 June 2007).

Action A.2 and Action A.3 have been carried in close connection and with the same contractor. The total cost of Action A.2 and A.3 amounts to 119.785Euro.

	<i>Budget</i>	<i>Incurred cost</i>	<i>Discrepancy</i>	<i>%</i>
Action A.2	64.603			
Action A.3	55.182			
<i>Action A.2+A.3</i>	<i>119.785</i>	<i>109.200</i>	<i>-10.585</i>	<i>-8,8</i>

6.1.4. Action A.4: Reef design and call for tenders

The contractor Orbicon A/S has carried out the action for developing a design for the nature restoration of the 1170 reef habitat at Læsø Trindel. Moreover the contractor has made the impact assessment on the Natura 2000 site.

The new reef structures has been designed taking into consideration the special requirement of the typical marine flora and fauna at boulder reefs and with the over all objective to restore a favourable conservation status for the 1170 Reef habitat. The new reef structure has further been designed in respect of the hydrographical conditions and sediment transport conditions at the restoration area in order to secure the stability of the new reefs as they must be able to withstand extreme weather conditions as storm event. The design was developed in close cooperation with the project partners and DHI, and a draft design was tested in the models set up by DHI. Based on the test results the draft design was revised and a second draft (final) design was tested.

In parallel with the design development the contractor made the material for the Action C.1 call for tender based on the final design. The final tender was announced as scheduled with deadline for submission of tender offers in August 2007. Orbicon also had to evaluate the tender result as part of the contract.

The result of the tender was very poor and DFNA was forced to cancel the tender according to the rules of public procurement as the two bids exceeded the economic threshold level. It was clear from the tender result that the design had to be revised as well as other adjustments. A supplementary contract was made with Orbicon to

optimise the design according to advices gathered. A revised design was developed during autumn 2007. The design was basically identical to the former design, but slightly reduced in the total amount of quarry stone and area and with fewer specifications for the restoration work. The proposed revised design fulfilled the objectives of the nature restoration project and restores the structure and functions of the threatened cavernous boulder reef and stabilize the existing reef habitat at Læsø Trindel. A favourable conservation status for the Natura 2000 reef habitat is still believed to be restored, but the area has been reduced from 6 ha to approximately 5 ha.

The reef design can be seen in Annex 1, where E1 and E2 show the areas on the original reef that has to be stabilized. E2 is an area where the boulders should be placed very carefully because the reef slopes are steep. M1, M2, W1 and W2 show areas for new reef structures. The rectangular area (M1) is an area where the boulders should be placed more or less in one layer. The circular areas are markings of cones were the boulders must be stacked to make cavernous structures and establish the possibility for different diversity at different depths of water.

A modification request for the revised design was prepared and sent to the Commission on 10 January 2008 and approved by the Commission on 20 February 2008.

The impact assessment for the Natura 2000 site estimated that only for a very short period of time when the work is ongoing there might be negative influence on plants and animals at the Natura 2000 site. After the restoration work has finished it is estimated that the new reef structures will contribute to favourable conservation status for the reef habitat.

The report “Naturgenopretning af stenrev på Læsø Trindel – Design beskrivelse og konsekvensvurdering” (English Summary) describes the results and is available on the project web site, www.blureef.dk

Action A.4 was started 22 December 2006 (foreseen ultimo 2006) and ended 05 November 2008 (expected 1 June 2008). The Action has been prolonged due to the poor tender result in August 2007 and the need for a supplementary contract for the revised design

The cost of Action A.4 amounts to 85.443 Euro.

	<i>Budget</i>	<i>Incurred cost</i>	<i>Discrepancy</i>	<i>%</i>
Action A.4	69.987	85.443	15.456	22,1

6.2. Non-recurring biotope management

6.2.1. Construction of cavernous reefs at Læsø Trindel

The constructor: Hoffmann A/S

As described under chapter 6.1.4 the first call for tender for the reef restoration was conducted in the summer 2007 but the DFNA had to cancel the tender. The new tender

procedure was held from 8 February 2008 to 13 March 2008. Hoffmann A/S was chosen for the construction work. Copy of selection procedure documents, contracts etc have been dealt with during the monitoring visit 24-25 June 2010 as mentioned in the Commissions letter of 18 August 2010.

To advise about the pre-qualification of constructors and call for tender on the construction work, the building consultant Sund og Bælt (Sound and Strait) was contracted. Moreover Sund og Bælt should advice on technical specifications, the contract and the special conditions of the contract.

The building consultant: NIRAS A/S

A tender for an external building consultant regarding supervision of the contractor's work on the reef construction was conducted from 29 February 2008 to 26 March 2008. NIRAS A/S was chosen as technical advisor and was responsible for the supervision of the contractors work in regards of the contract specifications.

Marking of the project area

A contract was made with the Royal Danish Administration of Navigation and Hydrography (Farvandsvæsenet) on placement and inspection of the required marking of the project area while the construction work went on. Such a marking is required for the sake of the shipping. At the same time the Danish Maritime Authority was asked to prohibit unauthorized entrance to the project area.

The construction work

Hoffmann A/S started the construction work in June 2008. The constructor collected the boulders from a quarry on Kragerø in southern Norway where the boulders were blasted from bedrock of the type hyporit/norit. To be able to select the right sizes of boulders, some of the boulders had been weighed. The weight in kilogramme was written on some of the boulders that were kept in the quarry for comparison. The boulders for the restoration work should weigh between 0.6 tons and 6 tons. At the quay of the quarry the boulders were loaded on a 120 metre long and 30 metre broad barge. The barge could carry 12.000 tons of load.

From Kragerø the loaded barge was taken in tow by a tug to Læsø Trindel. When the barge got to the position for unloading two excavators and a loader tractor unloaded the boulders. The quantity of unloaded boulders and their position was estimated by weighing how much weigh an average bucket could carry and by having geographical positioning equipment on the excavators and on the loader tractor.

During the construction work it was decided that the budget could allow more boulders delivered for which reason a supplementary contract was made with the constructor. In practice it implied that one more shipment of boulders was delivered. In the supplementary contract with Hoffmann A/S it was specified that the extra boulders should be used for extra stabilization of the existing reef. In total eight barges with 58.896 m³ and 100.712 tons of boulders were taken in tow to Læsø Trindel.

In spite of geographical positioning equipment it was not possible for the machines on the barge to place all the boulders in the correct position. Therefore a vessel formerly

used for fished up boulders from the sea floor adjusted some of them to the right position.

The construction work was at first delayed due to a poor tender result and next due to bad weather conditions during the period for control scanning of the performed works. The fact that Læsø Trindel is situated in open waters makes the area exposed to wind and current. Another fact is that The Baltic Sea has its outflow through Skagerrak which is relatively narrow compared with the Baltic Sea body. This implies that even in calm weather there can be high velocity current in the area making scanning and working with the boulders impossible.

During a windy period in July 2008 the barge loaded with boulders was at anchor at Læsø Trindel while the constructor waited for calm weather. Because of the strong wind the anchor was torn up and the barge started drifting eastwards. It did not stop till the anchor became fixed to an underwater electric cable. The questions on indemnification to the electric company were a matter between the insurance companies of the involved partners and were irrelevant to the DFNA.

During the summer 2008 some yachts got into the working area and collided with the boulders. In order to prevent further collisions web sites concerning yachting were contacted to write about the reef and the risk of collision. Moreover a small poster was produced and hung up in harbours in Northern Jutland and on Læsø in September 2008.

The construction work was finished in September 2008. At that time the constructor's quality control showed that the work was done and the quality control was approved by the external building consultant. A side scan carried out by Dansk Søopmåling, see Section 6.4.3, revealed that the stabilization of the remaining reef (E1 on the map in Annex 1) was not successful. To fulfil the contract the constructor had to move part of the boulders. The constructor finished the work in June 2009.

The construction work is presented in the video produced in Action E.4

The Action C.1 was started 1 May 2008 (foreseen 1 October 2007) and ended in June 2009 (foreseen 1 May 2008). The construction work was first delayed due to a poor tender result and next due to bad weather conditions during the period of control scanning of the performed works.

The cost of Action C.1 amounts to 3.536.998 Euro.

	<i>Budget</i>	<i>Incurred cost</i>	<i>Discrepancy</i>	<i>%</i>
Action C.1	3.600.000	3.536.998	-63.002	-1,8

6.3. Public awareness and dissemination of results

6.3.1. Action E.1: Mounting of information boards

In April 2010 a contract was made on producing and lay-out of the information boards. The material was produced but printing and mounting of the boards were postponed until 2011 as a consequences of the financial crisis and Danish Governments plan for financial re-establishment in May 2010. Instead temporary information boards was printed in A3 and placed on central information hot spots on the Island of Læsø.

The Action was due to change of project staff postponed until May 2012 where it was decided to revise the design due to new logo for DNA and at the same time the text could be updated. Each information board includes two plates and prints of the plates are attached as Annex 2. The plates have been printed in A3 size and in a larger size (“højskilt”, e.g. 99 cm x 74 cm.).

The permanent information boards have been mounted at the yacht harbour of Frederikshavn and on the ferry to Læsø, both A size. Information boards have also been mounted at Østerby Harbour and Vesterø Harbour (both “højskilt” size), but due to construction works within the harbour area the boards were mounted in June 2013. It has not been possible to make an agreement with the Læsø ferry terminal at the traffic harbour area of Frederikshavn because the limited available wall space is already used for leaflets. Photos of the mounted information at Frederikshavn yacht harbour (A3) and at Østerby Harboar (“højskilt”) can be seen in Annex 3.

The Action E.1 was started in April 2010 (foreseen autumn 2007) and ended in June 2013 after the end of the project. First the Action was delayed as a consequences of the delay in Action C.1 and further the Action was delayed due to financial restrictions, change of project staff and construction works at harbours.

The cost of Action E.1 amounts to 12.503 Euro.

	<i>Budget</i>	<i>Incurred cost</i>	<i>Discrepancy</i>	<i>%</i>
Action E.1	16.546	12.503	-4.043	-24,4

6.3.2. Action E.2: Production of a Layman´s report

A Layman´s report have been produced in Danish and English at the end of the project. The report includes summary of project scope and objectives, an assessment of the conservation benefits for the 1170 Reef habitat and transferability of the project results.

The Layman report is attached as Annex 4.

The report is available on the projects website www.blureef.dk and will be distributed to the secretariat for HELCOM and OSPAR Conventions, the secretariat for ICES, the Advisory Board, relevant danish environmental interest groups, Danish aquariums and relevant danish municipalities and others who have shown in interest for carrying out restoration projects.

The cost of Action E.2 amounts to 7.948 Euro.

	<i>Budget</i>	<i>Incurred cost</i>	<i>Discrepancy</i>	<i>%</i>
Action E.2	12.151	7.948	-4.203	-34,6

6.3.3. Action E.3: Project Internet Web Site

The BlueReef web site was set up and launched in 2006. From the start the web site contained detailed information on the project, maps of the Natura 2000 site and the project area, description of the 1170 reef habitat etc. The web site was in Danish with an English summary.

Through the project period the web site has been developed further and updated regularly with reports, dissemination activities, photos etc. Furthermore some text in English has been added and the web site has been updated with correct logo. The web site is accessible from its own address: www.Blureef.dk and from the DNA's homepage.

In order to improve an international dissemination the English text was extended and improved in January and February 2013 before the international symposium (se Action E.6). As a result all the parts of the web site is now both in Danish and English.

The cost of Action E.3 amounts to 9.499 Euro.

	<i>Budget</i>	<i>Incurred cost</i>	<i>Discrepancy</i>	<i>%</i>
Action E.3	10.171	9.499	-672	-6,6

6.3.4. Action E.4: Video on marine boulder reef restoration

In May 2007 the National Broadcasting Corporation (DR) was contracted to produce a BlueReef LIFE documentary video and a programme in the DR's scientific series "Viden Om" (i.e. knowledge of).

The "Viden Om" programme was broadcasted the first time on 28 October 2008. The programme shows the process from modelling of a new reef design to blasting of boulders in Norway and unloading the boulders at Læsø Trindel. On the first programme there was unfortunately no mention of the LIFE contribution and only the LIFE logo was displayed as pointed out by the Commission in letter of 12 November 2019. In spring 2010 a new version of the programme was produced with both the LIFE logo and the Natura 2000 logo. Further in the introduction to the programme a text has been added about the LIFE contribution saying that EU LIFE has financed half the cost of approx. 35 mill. DKK. From the project web site (Blue Reef/News) there is a link to the programme at DR homepage (Find programmer/2009). A direct link to the programme can be found here <http://www.dr.dk/tv/se/viden-om/viden-om-laesoe-rev-web#!/>

The Blue Reef documentary video was produced in February 2013 both in a Danish and an English spoken version. The video document the activities from the initial field investigations and modelling and design, to the construction of the reef and the colonization of fauna and flora. The video with English speaking is attached as annex 5.

The video has been presented at the final public meeting at Læsø (Action E.5), to the Advisory Board and at the international symposium (Action E.6).

The video is available on the web site where it can be downloaded/streamed. Only the Danish spoken version is available but the English version can be sent by request. Furthermore 3 small sequences from the video (danish speaking) showing the restored reef, the construction work and an computanimated model of the reef has been put on the web site. The video and the sequences are also available on YouTube.

The video has been forwarded to Læsø Lystfiskercenter and the following danish aquariums: Øresundsakvariet (Helsingør), Kattegatcentret (Grenå), Nordsøcentret (Hirtshals) and Den Blå Planet (Kastrup). All the aquariums have educational activities for schools.

The cost of Action E.4 amounts to 60.564 Euro.

	<i>Budget</i>	<i>Incurred cost</i>	<i>Discrepancy</i>	<i>%</i>
Action E.4	49.930	60.564	10.634	21,3

6.3.5. Action E.5: Information to the local communities and the public

The action contains different dissemination activities including public meetings, articles and presentations at conferences etc.

There has been held 3 public meetings) on the island of Læsø. All the meetings have been held at the local village hall (Læsø Forsamlingshus). The meetings have been attended by 35 – appr. 100 people. The meetings have been covered or referred to by the regional television.

- *First meeting (March 2007)*: The purpose of the meeting was to inform about the Blue Reef project, Natura 2000 in general and the expected results.
- *Second meeting (November 2008)*: The purpose of the meeting was to inform more about project progress, the construction work and the baseline survey of the biological monitoring programme. Moreover information was given about the Danish proposal to new marine habitat sites including the enlargement of the Natura 2000 site around Læsø.
- *Third meeting (January 2013)*: The purpose of the meeting was to inform about the results of the biological monitoring programme and to discuss the future management of the restored reef. Furthermore the meeting was used to evaluate the project and the process giving input to the codes of conduct (See Action E.6).

Public meetings have been planned annually. No public meetings were held between November 2008 and January 2013 as there was no major development in the project and no issues had been raised by the local community.

In relation to the baseline survey of the biological monitoring programme an “Open Ship” event was arranged in June 2007 at the harbour of Østerbye on Læsø.

The project has been referred to in many articles in local newspapers and other media during the project period and especially in relation to public meetings and major milestones.

DNA and the partners have on several occasions presented the Blue Reef project. A list of presentations can be seen in the Disseminations list shown in Annex 6.

The action has been ongoing from the project start 1 August 2006 until the project end 1 April 2013.

The cost of Action E.5 amounts to 30.808 Euro.

	<i>Budget</i>	<i>Incurred cost</i>	<i>Discrepancy</i>	<i>%</i>
Action E.5	28.285	30.808	2.523	8,9

6.3.6. *Action E.6: International Seminar on Marine Nature Restoration*

International Symposium

An international Symposium on “Marine Nature Restoration in Northern Europe” was held in Copenhagen 11.-12. March 2013.

The purpose of the symposium was to bring different stakeholders including national authorities, NGOs and various relevant marine nature restoration initiatives together in order to share experiences and discuss the way forward for the role of marine nature restoration in Northern Europe.

Three following three speakers were selected among internationally leading scientist/managers: 1) Jon Day, Director of Planning, Heritage and Sustainable Funding, Great Barrier Reef Marine Park Authority, Australia, 2) Henning von Nordheim, Head of Marine and Coastal Nature Conservation, Federal Agency for Nature Conservation, Germany and 3) Aad Small, Professor Wageningen University, The Netherlands. Transport, accommodation etc for the three speakers were covered by the project.

The programme contained key-note lecturers and presentation of marine nature restorations projects in Denmark, Germany, Norway, Sweden and the Netherlands. The Blue Reef project was covered by a number of presentations. The symposium was attended by about 65 scientist, managers and others from 8 different European countries.

The programme and the presentations from the symposium is available on the Blue Reef web site, www.blureef.dk

The report “International symposium on Marine Nature Restoration in Northern Europe” describes the symposium including programme and list of participants and is available at the Blue Reef web site www.blureef.dk and is enclosed as Annex 7.

In order to increase awareness on marine management and conservation issues Jon Day participated 13 March 2013 in a meeting with relevant Danish authorities to discuss marine protected areas and gave a lecture about Ecosystem based management at the University of Copenhagen as part of Copenhagen Sustainability Lectures. Programme for the meeting and invitation to the lecture are attached in Annex 8.

A review based on the theme of symposium is considered by partners and participants at the symposium.

Codes of conduct

“Codes of conduct” for the establishment of stone reef has been produced in English and Danish. The English version is attached in Annex 9.

The “Codes of conduct” contains recommendations and guidelines in regard to the restoration of natural stone reef. It also include a section with information about relevant Danish authorities and where and how to apply for permission to restoration projects.

The “Codes of conduct” has been elaborated in close cooperation with the project partners, eg. AU and DTU Aqua, and has further been formed through input from the public meeting held on Læsø (see Action E.5), the Advisory Board including the divers club in Frederikshavn and a seminar discussion held at the international symposium. The section about Danish authorities and permissions have been elaborated in collaboration with the relevant authorities.

The “Codes of conduct” contains no new regulation in Danish law. The purpose is to align and disseminate experiences and best practise for restoration of natural stone reef based on the Blue Reef project both national and international.

The codes of conduct and will be distributed to the secretariat for HELCOM and OSPAR Conventions, the secretariat for ICES, the Advisory Group, relevant danish environmental interest groups and relevant danish municipalities and others who have shown in interest for carrying out restoration projects.

The codes of conduct is available on the project web site www.blureef.dk

The Action E.6 has been started in started in October 2012 (foreseen October 2011) and ended in March 2013 (foreseen March 2012). The dealy is due to the extension of the project by one year.

The cost of Action E.6 amounts to 23.271 Euro.

	<i>Budget</i>	<i>Incurred cost</i>	<i>Discrepancy</i>	<i>%</i>
Action E.6	21.094	23.271	2.177	10,3

6.3.7. Action E.7: Under water trail

From water trail to diver leaflet

The establishment of an under water trail with markers in the form of coloured boulders placed at sites of special interest was given up in 2010 because the area was more exposed to wind and current than anticipated. The exposed conditions would make diving on the reef challenging and divers would often have to find the side of the reef with less current. As an alternative it was decided to produce a leaflet describing how to dive on the reef. The modification was accepted by the Commission as a non substantial change to the grant agreement in a letter dated 18 august 2010.

In December 2012 a contract was made for the production of a leaflet addressing divers and other visitors to the reef. The leaflet gives information about interesting places to dive and presents the results from the monitoring from 2012. The leaflet contains text in Danish and with a comprehensive summary in English for international visitors. The leaflet is attached as Annex 10 and is available at the project web site www.blureef.dk

The leaflet has been printed in a number of 1.100 which have been distributed to local tourist agencies and the ferry terminal at Frederikshavn. Further a web version of the leaflet has been forwarded to different fishing, diving and yachting organisations in Denmark and Sweden.

Diver buoy and sailing safety

In order to help divers to get to the right position and not to hit the boulders a marker buoy was put out in June 2009 attached to a boulder using a screw eye. The marker buoy however detached in the start of 2010 most likely because of ice pack around Læsø.

A new marker buoy was ordered in 2011 and put out in July 2012 by using an anchor chock and a wire. Photos of the new buoy can be seen in Annex 11. Later in August a small anchor buoy was attached. The new marker buoy however detached later in October 2012 most likely due to strong wind in the area. A marker buoy outside the harbour at Østerby detached at the same time.

At the public meeting at Læsø in January 2013 there was a strong request for a better marking of the new reef.

A plan for combining the diver buoy and sailing safety was prepared from February to the end of the project (1 April) with the Danish Maritime Authority. The plan involved putting out a new marker buoy at a new position, where it can serve both as a point of interest for divers and a safety warning for yachts and other boats.

The plan has been in hearing in the local weekly (Læsø Posten) in June 2013 and an agreement about maintaining the buoy will be made with the Danish Maritime Authority.

The Action E.7 was started in 2009 (foreseen 2008) and ended in March 2013 (foreseen July 2008). The Action has first been delayed one year due to the delay of Action C.1 and later by several years due to the detaching of buoys and discussions of new solutions.

The cost of Action E.7 amounts to 17.272 Euro.

	<i>Budget</i>	<i>Incurred cost</i>	<i>Discrepancy</i>	<i>%</i>
Action E.7	7.685	17.272	9.587	124,7

6.4. Overall project operation and monitoring

6.4.1. Action F.1: Project management and co-ordination

The Steering Group has held 4 meetings from project start until 31 December 2008, one meeting in November 2010 and one meeting in November 2012. The meetings have typically been in connection to the major milestones and decisions. In between the meetings the group has been kept informed of the project progress by notes. The chairman and other members of the Steering Group have taken part in the public meetings, meetings with the Advisory Group and the international symposium (See Section 6.3.6) and have further contributed to an overall dissemination of the project at different conferences and seminars.

The Advisory Group was set up prior to the first public meeting in March 2007, where 8 authorities and 15 interest groups accepted an invitation to participate. There has been held 3 meetings with the Advisory Group all in connection with the public meetings (See Section 6.3.5). As many of the members have been from the northern part of Jutland, the meetings have been held in Frederikshavn and Aalborg. The Advisory Group has contributed with stakeholder views on local involvement and advice on technical and scientific issues.

There have been three different project managers on the project: Annie Hougaard Dalgas (01/08/2006 – 01/07/2008), Else Marie Stamphøj (01/07/2008 – 01/05/2012) and Jakob Harrekilde Jensen (01/05/2012 – 01/07/2013). Oluf G. Christiani from DNFA had the overall project responsibility from 01/10/2007 – 31/12/2010, when ASEP was partner.

The daily project management has been conducted according to the project activities and from 01/05/2013 onwards organised as a team with project manager and two project members. Project management has, often in close collaboration with partners, involved preparation of meetings in Steering Committee, Advisory Group and public meetings. Further meetings have been held with partners, national authorities especially regarding the necessary approvals etc. for the constructions works Action C.1,

contractors and consultants and the external monitor. The project manager has also contributed to dissemination of the project at international and national conferences and seminars.

The Action has been ongoing from the start until the end of the project.

The cost of Action F.1 amounts to 144.754 Euro and includes the elaboration of the After-LIFE Conservation Plan (Action F.4).

	<i>Budget</i>	<i>Incurred cost</i>	<i>Discrepancy</i>	<i>%</i>
Action F.1	135.946	144.754	8.808	6,5

6.4.2. Action F.2: Biological Monitoring Programme

The partners UA and DTU Aqua are responsible for the Biological Monitoring Programme including reporting on annual surveys and results.

After the finish of construction work there has been a prohibition of fishing at the restored reef and in area around it. The prohibition was suspended by 31 December 2012.

The “Blue Reef” monitoring programme has used a “BEFORE - AFTER” approach with monitoring activities before and after the restoration of the boulder reef. A baseline study was carried out at Læsø Trindel in 2007 focusing on a number of key variables describing the overall quality of a reef habitat before the restoration project began. In 2012 the area was revisited using the same methodology and sampling programme. Samplings included quantitative suction sampling for benthic fauna and algal species, fyke net and gillnet sampling for fish species and traps for lobster and crabs.

Biological diversity

The overall diversity on the reef, in terms of identified distinct species, is only slightly higher in 2012 compared to 2007 (figure 1 in Annex 12). In 2007 a few samples were taken on large remaining boulders with a high number of species and the samples in this figure also represent infauna collected on gravely-sandy sediments. On the other hand, the overall area sampled in 2012 was 33% larger than the area sampled in 2007 and most often one can find a correlation between species numbers and sample area.

Improved biomass on the reef

Restoration of the reef has so far resulted in an overall increase in biomass of almost 6-8 fold on the two depth intervals 5-6m and 9-10m. Brown and red algal species made up the majority of biomasses in 2007. The two algal groups were still dominant in 2012 but the anthozoan, *Metridium senile*, was found with very high biomasses as well (figure 2 in Annex 12). *M. senile* was not recorded at all on the reef before the restoration project was initiated. There has been a shift towards a higher proportion of perennial algal species with higher biomasses. Some of the increment is due to the larger surface area created by the large boulders compared to the former seabed.

Abundance of individual fauna species

The overall number of individual species increased considerably at Læsø Trindel at the newly established boulder reef compared with the situation in 2007 (figure 3 in Annex 12). The increase was more than 4-fold at 5-6m depth and more than 6-fold at 9-10m depth. Bivalves were relatively more dominant in the investigation in 2007 whereas crustaceans and to some extent gastropods and anthozoans have taken over in the 2012 investigation.

Cod abundance increased in the vicinity of the restored reef and was most evident in the shallow boulder reef area at 2-6m depth (figure 4a and 4b in Annex 12). This was evident from both sampling methods, the gillnets and fyke nets. Furthermore, rock-affiliated fish belonging to the wrasse family showed a higher affinity to the shallow part of the reef but the increase in abundance was primarily in the surrounding deeper areas (6-10m) of the reef in the gillnet samples. Flatfishes declined in abundance after the reef restoration in the shallow part of the reef where the cavernous boulders were established. This was significant in the gillnet samples. For the remaining fish community, there was no significant changes over time for any of the sampling methods.

Lobster, remained at very low levels also after the restoration. Lobster is a slow growing species that mature around age 5 to 6 years. An increase in the lobster population due to local recruitment can therefore not be expected to be detected within the 4 year period investigated. Any abundance enhancement can thus only originate from a migration of adult lobsters from adjacent areas which apparently have not taken place.

The main prey item for cod both before and after restoration was crustaceans (figure 5 in Annex 12). After the reef restoration, there was a generally higher biomass of crustaceans in cod stomachs. The main crustaceans observed in the cod stomachs before and after the reef restoration were Gammaridae. The largest increase in prey biomass in the cod stomachs after the restoration was also Gammaridae, reflecting the higher biomasses of these species found on the restored reef (see results on benthic fauna). Furthermore fish were first observed in cod stomachs after the restoration.

The results on the length distributions showed an increase in fish size distribution after the reef restoration. Closer analyses using single species showed this was due to the increased occurrence of cod, which consisted mainly of larger juvenile cod.

Overall conclusion and perspectives

The ecological benefit of the restoration project is an estimate of an extra gain in macroalgal vegetation and bottom fauna of approximately 6 and 3 ton ash free biomass respectively. The project also resulted in an estimated surplus of nearly 700 mill solitary fauna individual. The ecological benefit is expected to increase further in the years to come due to an expected positive development in the per-annual algal vegetation with larger fraction of per-annual species and larger individuals.

Mainly gadoids and reef fish benefitted from the restoration of the reef. Cod increased on average three to six-fold in the reef area, especially in the shallow part where the cavernous reef structure was restored. The larger juvenile individuals of cod were attracted to this shallow part of the reef and they profited from the increased food

available, mostly gammarids, which was the dominant prey item in the cod stomachs both before and after the restoration. The results of the stomach analyses demonstrated a benthic-pelagic coupling in the reef area, strengthened by the restoration of the reef. The increase in wrasses was less dramatic and was observed in the peripheral, deeper area of the reef.

Compared to observation of species composition and overall development of the algal vegetation at other boulder reefs in Kattegat, it is argued that the biological development in 2012 is far for a climax community. More species and first of all higher biomasses is expected in the years to come.

The report “Ecology of Læsø Trindel – A reef impacted by extraction of Boulders” presents work from the baseline study programme of a selected number of key variables describing the overall quality of the reef habitat at Læsø Trindel before the construction works began. The report is available at the web site www.blureef.dk

The reports “Blue Reef – status for den biologiske indvandring på Læsø Trindels nye rev i 2009” and ” Blue Reef – status for den biologiske indvandring på Læsø Trindels nye rev i 2010” presents results of the colonisation of flora and benthic fauna on the reef after one respectively two years after the construction works. The reports are available at the web site www.blureef.dk.

The report for monitoring in 2011 is attached in Annex 13 while the monitoring report in 2012 2 is included in the final report.

The final report “Ecological benefits from Restoring a Marine Cavernous Boulder Reef in Kattegat, Denmark” describes the methodology and final results from the monitoring programme. The report to the Commission is available at the web site www.blureef.dk and is attached in Annex 14.

The Action F.2 was started 1 November 2006 (foreseen 1 November 2006) and ended 1 May 2013 (foreseen 1 May 2012). The delay is due to the extension of the project with one year as the deployment of boulders was delayed from autumn 2007 to autumn 2008. The extension secured a colonization period of 3 ½ year as originally planned in the Grant Agreement.

The cost of Action F.2 amounts to 544.276 Euro.

	<i>Budget</i>	<i>Incurred cost</i>	<i>Discrepancy</i>	<i>%</i>
Action F.2	523.853	544.276	20.423	3,9

6.4.3. Action F.3: Post bathymetry and stability of reef structures

The first post bathymetry was carried out by Dansk Sjøpmåling as a subcontract between the external building consultant (NIRAS A/S) and Dansk Sjøpmåling.

The side scan revealed that the stabilization of the remaining reef (E1 on the map in Annex 1) was not successful, and the constructor had to move part of the boulders. The

data from the side scan was given to the Royal Danish Administration of Navigation and Hydrography for updating the chart.

The first bathymetry was started in September 2009 (foreseen 1 October 2008) and ended 3 March 2009 (foreseen 15 November 2008). The bathymetry was delayed due to bad weather conditions and accident with the equipment as the contractor collided with the boulders.

The second bathymetry was carried out in August 2012 by Dansk Søopmåling after calling for tenders.

A comparison between the first and the second bathymetry survey revealed that the position of the boulders are stable.

The data from the second bathymetry has been given to the Danish Geodata Agency for updating the chart. The Agency is responsible for the chart after the Royal Danish Administration of Navigation and Hydrography.

The second bathymetry was started in May 2012 (foreseen 2011) and ended in August 2012 (foreseen 1 September 2011). The delay is mainly due to the extension of the project.

The report “Post bathymetry and stability of reef structures” describes the methodology, results and conclusions of the two post bathymetry surveys and is available on the project web site, www.blureef.dk and is attached in Annex 15.

The cost of Action F.3 amounts to 48.952 Euro.

	<i>Budget</i>	<i>Incurring cost</i>	<i>Discrepancy</i>	<i>%</i>
Action F.3	55.182	48.952	-6.230	-11,3

6.4.4. Action F.4: After-LIFE Conservation Plan

An After-LIFE Conservation Plan has been elaborated, where the main activities is protection of the new reef, safety for yachtmen and dissemination of the project through website, information boards and leaflets.

The After-LIFE Conservation Plan is attached in Annex 16 and is available on the project web site, www.blureef.dk

The Action was started in January 2013 (foreseen 2011) and ended in March 2013 (foreseen 1 April 2012). The delay is due to the extension of the project.

7. EVALUATION AND CONCLUSIONS

7.1. The process

The project has been one of the first restoration projects of its kind and it has been very rewarding and challenging to work on a “pioneer-project”.

In general the project has experienced a good process in relation to the EU LIFE and external monitoring team. The external monitor has given very qualified advice in due time. The fact that the same monitor has followed the project all the way has been very valuable taken the long project period into consideration.

The setup with a Steering Group and an Advisory Group has been very valuable for the project management.

The Steering Group has secured co-ordination and project progress. The chairman and members have with their experience in leadership and high knowledge and experience within marine biology, provided excellent guidance to the project management.

The Advisory Group has contributed with valuable local knowledge to the project managers, who all have been attached to the central part of the DNA in Copenhagen.

The partners (AU and DTU Aqua) have both added a huge value to the project with their great knowledge and experience about monitoring and reefs. As partners they have had a big ownership to the project and have contributed with valuable input to other part of the project such as public involvement and elaboration of code of conduct. Two additional projects have been financed and carried out by the partners to support the Blue Reef project. AU has investigated in the effect on the small cetacean Harbour porpoise and DTU Aqua has investigated in cod behaviour on the reef using telemetry.

It has been possible to keep interest and commitment in a project with a long timespan (80 months) including the period from the end of the construction works to the final monitoring took place.

7.2. The project management

Due to a change in the organisation at the former DNFA the professional competence on marine aspects was placed in a new agency (ASEP). As a result ASEP was included as a new partner with responsibility for the majority of the contract until DNFA and ASEP merged from 1 January 2011 to form DNA.

At DNA there have been three different project managers due to change in organisation during the project period of 80 months, and it has been challenging to transfer knowledge and experience to a new project manager twice during the project. Due to commitment and dialogue with former project managers the management has worked.

Both the partners have experienced a change in organisation, but there has been no implication as there has been no change in rights and obligations. Further there has been no change in the monitoring experts involved, which have been of great value for a monitoring programme covering a period of approximately 5 years.

7.3. Success and failures

The *Preparatory actions* have in general been successful and have provided valuable results and information for the design on the reef. The seabed has been estimated as stable and solid ground for the reef construction and the modelling of sediment transport have shown no consequences for the nearby habitat 1180 (Submarine structures made by leaking gases) and the Østerby Harbour on Læsø.

The two bids at the first tender was however too expensive and a revised design had to be developed based on a slightly reduced amount of boulders and with fewer specifications for the restoration work.

The *Non-recurring biotope management* (Construction of cavernous reefs) has been carried out successfully. The boulders have been transported to Læsø Trindel and placed in the correct position during the summer 2008, and only a small adjustment had to be carried out in June 2009 based on the first post bathymetry.

The project area was well marked according to the authorisation while the construction work went on. Despite of this some yachts got into the working area and collided with the boulders during the summer 2008. In order to prevent collisions web sites concerning yachting in Denmark and Sweden were contacted and a poster was produced and hung up in harbours in Northern Jutland and on Læsø in September 2008.

Concerning *Public awareness and dissemination of results* the international symposium was successful with 66 participants from seven EU Member States and two representatives outside the European Union offering good opportunities for networking and dissemination of the lessons learnt during the project. Further the documentary video has been of excellent quality. It has been distributed to several aquariums and is in high demand. Finally the “Codes of conduct” is a valuable collection of recommendations and guidelines in regard to the restoration of natural stone reef and has been sent to several Danish municipalities and others who have shown an interest in restoring natural stone reef.

The establishment of a water trail had to be given up because the area was more exposed to wind and current than anticipated. Further the diver buoy which should help the divers to get the right position had been deployed twice but has detached each time due to ice pack or strong wind.

At the third and final public meeting at Læsø in January 2013 there was a strong request for a better marking of the new reef. This shows the importance of involvement of the local community.

The *Overall project operation and monitoring* has in general been successful. The Biological Monitoring Programme was extended with one year which has given very valuable and more consolidated results about the colonization of the reef.

The first post bathymetry survey was delayed due to bad weather conditions and accident with the equipment as the contractor collided with the new boulders.

7.4. Comparison against the project-objectives

The objectives of 1) restoration of the structure and function of the cavernous element of the shallow offshore boulder reefs and 2) stabilization of the top of the existing boulders have both been obtained.

The restoration has been carried out with natural stones from a quarry in the southern part of Norway and has been very expensive. The project cost should not be reduced by using other material, but the cost of stones could be reduced if the restoration of natural stone reef is considered or coordinated with marine infrastructure projects (windmills, bridges, tunnels etc) or projects at land, where natural stones have to be removed.

Some local fishermen claimed that the barge had lost some of the boulders - when it was unguarded and drifted away from the working area during a windy period in July 2008 - and that some of their nets were spoiled by the boulders. The constructor denied that the barge had lost any boulders. Construction work especially of this size has to be carried out with due respect to other interest and with necessary procedures in order to avoid conflicts.

During the summer 2008 some yachts got into the working area and collided with the boulders. After the working area has been removed and the chart has been updated some undocumented collisions have been reported. An important lesson learnt is that safety has to be taken very seriously and it is not necessarily adequate to rely on a marked working area and updated chart. As a stone reef restoration project results in changed sea levels the project management should consider additional marking and information to yachtsmen and others.

The objective of 3) increased awareness among environmental managers, policymakers and the broader public on marine nature restoration, conservation and management issues has also been obtained.

The international symposium and the different videos have together with the web site, leaflet, posters, signboards and articles about the project contributed to an increased awareness both at the international and the national level.

The dissemination of marine issues and marine nature restoration is very challenging and much more difficult than at land. The production of a documentary video has proved to be a very valuable way to disseminate marine nature restoration.

7.5. Environmental benefits, policy and legislation implications

The function and structure of the cavernous element of the boulder reef have been restored and the top of the existing boulder reef has been stabilised. The post bathymetry surveys have shown that the new reef structure is stable under the given conditions.

The ecological benefit of the restoration project is an estimate of an extra gain in macroalgal vegetation and bottom fauna of approximately 6 and 3 ton ash free biomass respectively. The project also resulted in an estimated surplus of nearly 700 million fauna individual. Changes in the fish community structure were also evident. Cod increased on average 3-6 fold in the reef area, especially in the shallow part of the rebuilt cavernous reefs. The ecological benefit is expected to increase further in the years to come.

An additional project carried out and financed by AU showed that the restored reef has proved to have an instant and positive effect on porpoise in the area. The porpoises occurred more often and also for longer periods of time and likely as a result of increased amount of prey. A presentation can be found on the web site www.blureeef.dk (symposium).

As a result of the project about 5 ha of offshore 1170 Reef habitat has been restored and stabilised. Further the restored reef can act as a donor-area.

The results of the restoration project prove that restoration of stone reef can be a valuable tool in obtaining and maintaining favourable conservation status in Natura 2000 sites.

The increased biomass indicates that restoration of cavernous boulder reefs may be a tool to achieve good environmental status in implementing the Marine Strategy Framework Directive.

The “Codes of conduct” can inspire others in northern Europe to restore natural stone reefs and it contains valuable experiences and recommendation for those who decide to carry out restoration projects. In a Danish context it also gives guidance to obtain the necessary permission from different marine authorities. Many of the recommendations are also relevant for the restoration of other marine nature types like biogenic reefs.

After the end of the monitoring programme fishing is no longer prohibited at or around the restored reef. Bottom trawling is a threat to stone reef and in order to protect 1170 Reef habitat the Danish AgriFish Agency is planning a prohibition for bottom trawling at stone reefs in Natura 2000-sites, including the Habitat site Læsø Trindel and Tønneberg Banke. The goal is to stop trawling at the reef and in a buffer zone of 240 m.

The local fishermen are critical about the planned prohibition of fishing. Not because of a stop for trawling on the reef itself but because the planned buffer zones can reduce the fishing potential in a larger area. The local fishermen are sceptical that the restored reef can contribute to better fishing by serving as a donor-area.

7.6. Innovation, demonstration value

The project is a very innovative project. Restoration of nature types has been used on land for several decades to enhance and to protect nature values. At sea, restoration projects are however only in their infancy and very little experience has been gained.

Many of the preparatory actions have been based on specific adapted models and studies. A wave model has been developed to simulate different wave height at different weather conditions. Numerical modelling has been used to predict the sediment transport before and after the reconstruction of the reef. The new reef structures have been designed taking into consideration the special requirement of the typical marine flora and fauna.

The project has come up with solutions to deal with the challenge of buying and transporting a large amount of boulders and to deploy the boulders precisely at the sea bottom under difficult conditions with strong wind and currents.

The project also has a huge demonstration value. It shows that marine nature restoration can contribute to restore nature marine values. It also shows that it can be done on a large scale and on a location with strong current and windy weather conditions.

Marine nature restoration projects are in general difficult to disseminate. The demonstration value of the project is supported highly by the production of a video documenting the activities from the initial field investigations and modelling and design, to the construction of the reef and the colonisation of fauna and flora.

7.7. Socio-economic effects

The island of Læsø is a small isolated island with only about 1.900 inhabitants and with a growing age group of +65 years. The major income is from fishing and tourism.

There has not been carried out any socio-economic analyses of the project and the obtained results. However at the international symposium the Director General at Læsø Municipality presented the following opportunities of the Blue Reef project for Læsø: guided tours for tourist, improved fishing near Læsø, and attention to Læsø as an exiting area of nature both on land and at sea.

Further the Læsø Municipal of Læsø is today partner in the LIFE⁺ project “LIFE LAESO – restoration of birdlife and natural habitats at Laeso” (LIFE11 NAT/DK/000893). The project involves nature management of about 4.000 ha of meadows by cattle and is expected to create new jobs.

7.8. Long term indicators of the project success

The long term indicators of the project success are:

- The new and restored reef structures remain stable

- The colonisation of the reef will continue with more species and first of all higher biomasses in the years to come.
- The “Codes of conduct” will be used in implementing project with restoration of natural stone reefs in Denmark

8. COMMENTS ON FINANCIAL REPORT

The table below gives the budget, incurred cost and the discrepancies for the different budget categories.

Category	Budget (€)	Incurred cost (€)	Discre- pancy (€)	(%)
Personnel	535.517	550.661	15.144	2,8
Travel, subsistence	36.051	37.615	1.564	4,3
External assistance	4.076.473	4.040.915	-35.558	-0,9
Durable goods				
-Infrastructure	0	0	0	-
-Equipment	3.324	0	-3.324	-
Consumables	44.334	46.742	2.407	5,4
Other costs	0	0	0	-
Overheads	112.699	109.417	-3.283	-2,9
TOTAL	4.808.398	4.785.349	23.050	

Table: Budget, incurred cost and discrepancy for budget categories

In general there is only a small discrepancy between the budget and the incurred cost both for the total cost as well as for the different categories. There has been no request for a modification of the budget.

Personnel

DNA and the partners AU and DTU accounts for 39 %, 38% and 23 % of the personnel cost respectively. The main items of expenditure for DNA has been in connection with 7 dissemination actions (Action E.1 – E.7) and project management (Action F.1), whereas the partners personnel cost have been in connection with implementing the biological monitoring programme (Action F.2).

Travel

The main items of expenditure has been in connection with *Action E.5 Information to local communities and the public* concerning cost of travel for members of the steering committee,

partners and project staff to public meetings at Læsø and meeting with the advisory group in different places in Northern Jutland and *Action E.6 International seminar on Marine Nature Restoration* where 3 international speakers have been invited to Copenhagen from Australia, Germany and Belgium. Further Jon Day from Great Barrier Reef, Australia stayed another day in Copenhagen to participate in a meeting and to give a lecture in order to increase awareness on marine management and conservation issues.

External assistance

The category accounts for almost 85 % of the total cost of the project. The major cost has been in connection to *Action C.1 Construction of cavernous reef at Læsø Trindel* which amounts to 3.536.998 Euro or 88 % of the total amount for external assistance.

Other main items of expenditure have been the preparatory actions including geological survey, modelling and reef design. All the preparatory actions amount to 239.087 Euro or 6 % of the total amount of external assistance.

At the international symposium (Action E6) the project had a revenue of 2.345 Euro from registration fee for participants.

Durable goods

The budget is based on expenditure to buy an underwater camera to the Biological Monitoring Programme (Action F.2). The camera was however not bought.

Consumable material

Consumables include mainly material such as chemicals (see Annex X), glass tubes, fishing gears etc. used as part of laboratory research and field work as part of the biological monitoring programme (Action F.3).

AU accounts for 57 % and DTU Aqua for 43 % respectively.

9. ANNEXES

No

- 1 Reef design
- 2 Print of Information Boards
- 3 Photos of Information Boards in place
- 4 Layman's report
- 5 Documentary video
- 6 Dissemination list
- 7 International symposium - report
- 8 Arrangements for Jon Day 13 March 2013
- 9 Codes of conduct
- 10 Diver leaflet
- 11 Photo of diver buoy
- 12 Biological Monitoring Programme – figures from final report
- 13 Biological Monitoring Programme – report from survey 2011
- 14 Biological Monitoring Programme – final report
- 15 Post bathymetry - report
- 16 After-LIFE Conservation Plan