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North Cage 2

Ólafur Ögmundarson
Róbert Hafsteinsson
Þorleifur Eiríksson
Böðvar Þórisson
Kristján G. Jóakimsson
Egil Lien
Jón Árnason

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Report summary

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Höfundar / Authors	Ólafur Ögmundarson og Róbert Hafsteinsson Matís, Þorleifur Eiríksson og Böðvar Þórisson NAVE, Kristján G. Jóakimsson HG, Egil Lien SINTEF, Jón Árnason, Matís. Aðrir samstarfsaðilar í verkefninu eru Hjalti Karlsson, Hafrannsóknarstofnuninni og Halldór Björnsson, Veðurstofu Íslands
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Ágrip á íslensku:

Verkefnið Norðurkví var sett á laggirnar til að:

- Hanna tæknilausn fyrir eldiskví til að gera eldismönnum kleift að sökkva henni og lyfta við íslenskar aðstæður.
- Hámarka notagildi sökkvanlegra kvía með tilliti til vinnuaðstæðna.
- Að viðbættu finna nýja lausn á meðhöndlun á netapokum í fiskeldi til að hrinda frá ásætum.

Áhersla þessa hluta verkefnisins, nefnt Norðurkví 2, er að hanna tæknilausn fyrir eldiskví sem hægt er að sökkva og lyfta aftur til að koma í veg fyrir skemmdir vegna rekíss. Að auki voru nokkrar nýjar tegundir meðhöndlana á netapokum prófaðar til að sjá hver af prófuðum meðhöndlunum hrinti best frá sér ásætum.

Lykilorð á íslensku: *Eldiskví, tæknilausnir, sökkva, hífa, netapokar, meðhöndlun*

Summary in English:

North Cage was established to:

- Develop sea cage technique to sink cages fit for Icelandic conditions.
- Optimise functionality of sinkable sea cages considering working conditions.
- In addition different types of netting and impregnation were tested in order to minimize the necessity of frequent change of nets in the cages.

This part, North Cage 2 of the North cage project is concentrated on the development of a cage that can be temporarily submerged and re-lifted to the surface to avoid the damage on the installation during the occurrence of drifting ice. In addition different types of netting and impregnation were tested in order to minimize the necessity of frequent change of nets in the cages.

English keywords: *Sea cage, technical solutions, sink, hoist, net bags, treatment*

Contents

Introduction

In the light of severe damage to sea-cages (Valdimar Ingi Gunnarsson, 2002) due to harsh weather conditions in Iceland this project, North Cage was established to:

- Develop sea cage technique to sink cages fit for Icelandic conditions
- Optimise functionality of sinkable sea cages considering working conditions

The aim is a sea-cage designed for Icelandic weather conditions which could strengthen the Icelandic farming industry.

The project North Cage, which is funded by Tækniþróunarsjóður Rannís (Technology development fund of the Icelandic Centre for Research) in 2008-2011, includes 2 work packages which were funded by AVS- Research fund in Fisheries, and are covered in this report. AVS funds are used to optimise the systems available for cage culture in Icelandic fish farming. The project is done in cooperation between the following companies and institutions:

Matís ohf
Náttúrustofa Vestfjarða
SINTEF
Hraðfrystihúsið Gunnvör
Hafrannsóknarstofnunin
Veðurstofa Íslands

This part, North Cage 2 of the North cage project is concentrated on the development of a cage that can be temporarily submerged and re-lifted to the surface to avoid the damage on the installation during the occurrence of drifting ice. In addition different types of netting and impregnation were tested in order to minimize the necessity of frequent change of nets in the cages.

The AVS fund granted 4,5 Millions to the project. Due to lack of funding (50% of original plan), and delay in the progress of the project the plan of the project was revised. This report includes the following work:

TECHNOLOGY SOLUTIONS:

WP 1 Sink/Hoist

Task 1.1 Development of comprehensive mechanism to sink and hoist, submerge and lift to the surface again a circular plastic collar fish cages, fast and safely under Icelandic conditions

Task 1.2 Test the efficiency of submerging and hoisting on location in Ísafjarðardjúp

WP2 Net

Task 2.1 Three different types of net materials were tested and four different types of impregnations of the nets on their durability in cod cages and the effect on bio fouling.

1. WP 1 Sink / Hoist

Rapid changes in weather conditions at the Icelandic coastline are one of the big challenges in sea cage farming section of Icelandic aquaculture. These rapid changes can result in drift ice which in large amounts has great momentum and may crumble floating sea cages. In order to prevent damages on cages trials have been made to steer the drifting ice away from sea cages, as well as trials to submerge cages beneath the ocean surface (sink). Sinking and hoisting cages appears to be more successful method to minimising losses of cages.

In this project information on currents and formation of drift-ice at the west coast of Iceland have been collected but the data is still unpublished. Based on the results obtained from the unpublished observations (Halldór Björnsson, 2010) , technique was developed as explained in Chapter 1.1.2-1.2. A circular plastic collar fish cages with capacity of containing up to 200 tons of fish, 5,5 m in diameter, 90 m circumference, 16 m in depth (depth of fish bag), weighing approximately 2 tons, here after referred to as the cage was developed.

In this report the following parts of the project will be addressed:

1. Design of sinking technique of sea cages for adjustment to weather conditions in the North-Atlantic.
2. Recommendation for modifications of sea cages for submersion.

1.1 Design of sinking techniques for sea cages with adjustment to weather conditions in the North-Atlantic

1.1.1 Introduction

To sink sea cages, the existing equipment was modified

The improvements can be divided into four steps.

1. Modifications on existing sea cage technology
2. Developing new sinking techniques
3. Techniques for stabilization of the submerged sea cage
4. Techniques for hoisting the cage to the surface

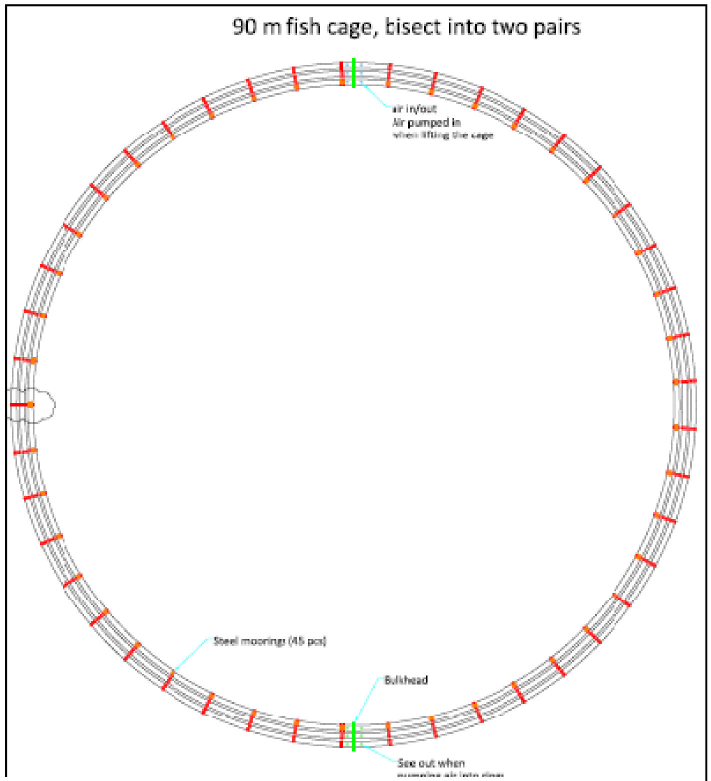


Figure 1. Sea cage with two cartridges with separate inlets for air and sea water on each side of the cartridge.

1.1.2 Modifications on existing sea cage technology

Each circle of 3 plastic collar of a typical fish cage was finally divided by inserting one separation, welding and adding pair of valves, inlet/outlet, for air and water to the rings, in order to facilitate the sinking process. The number of compartments needed for counteracting tilting of sea cage may depend on the circumference; the number was reduced from the original plan to speed up the sinking process.

1.1.3 Sinking/hoisting technique

Each compartment of the ring is equipped with pair of valves one at each end of the compartment, one valve is air in/outlet and one valve is water (sea) in/outlet as shown in Figure 2. To sink the cage the air valve is opened to release the air and water is inserted through the other (water) valve. Air compressor is connected to the air in/outlet when the cage is hoisted, and the water in/outlet is opened to remove the water at the same time. Valves are positioned vertical to the ocean surface, air valve on top of the compartment and water valve on bottom of compartment. The procedure of sinking and hoisting sea cage is described in Figure 3.

Using only an air compressor, but not combination of separate pump for water in- and ejection and air compressor is simplification and improvement from the original idea, which resulted from the work undertaken in this project.

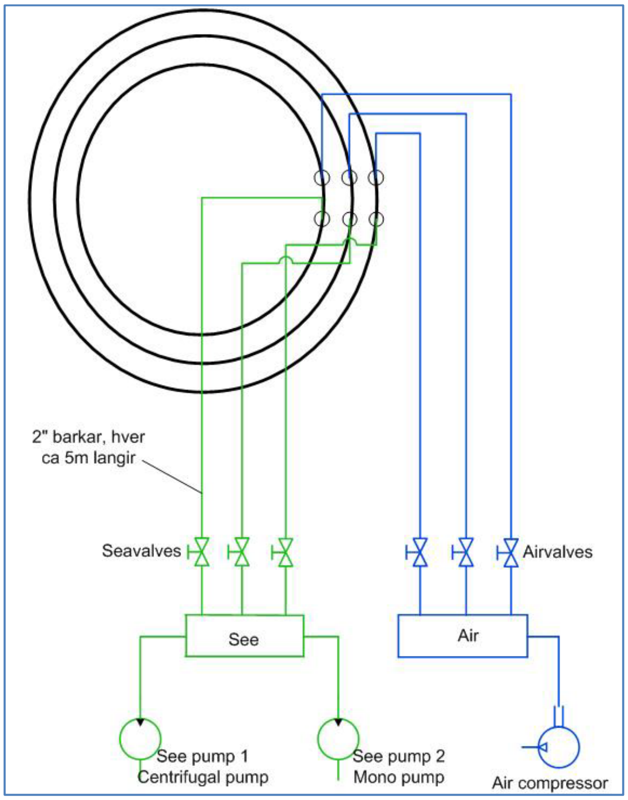


Figure 2. Valve arrangement for sinking/hoisting of the sea cage.

At surface level the air valves are above sea level, the sea water valves will be beneath the sea surface at all times. Air valves are fastened to a buoy. Diving is not required to operate water valves (Figure 3).

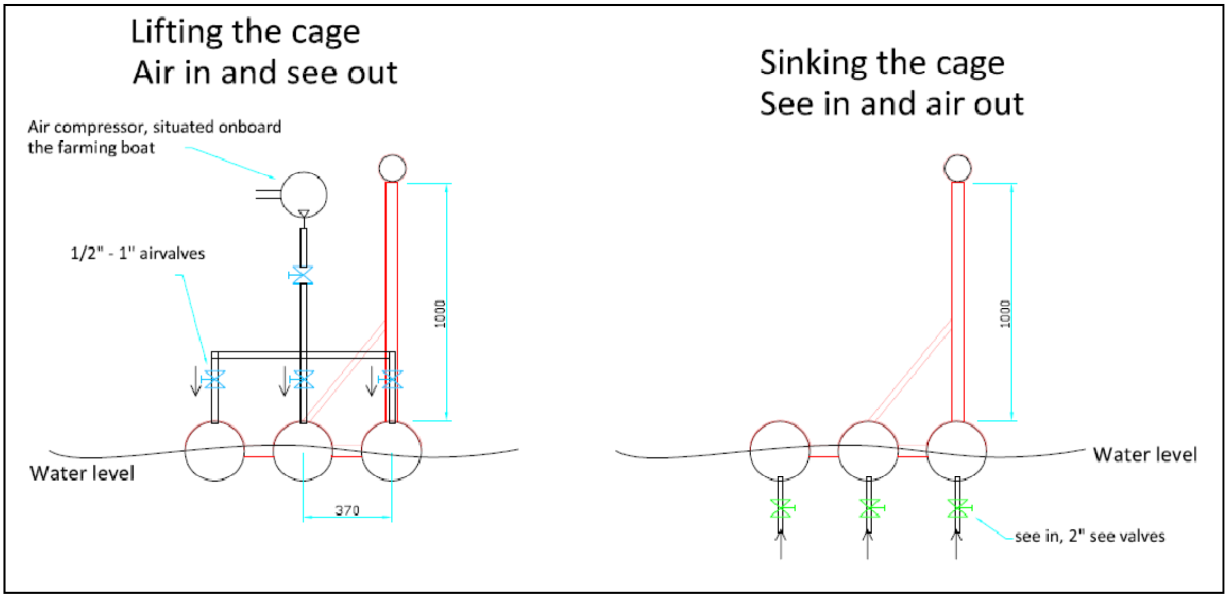


Figure 3. A detailed diagram showing valves for hoisting and sinking the sea cage

1.1.4 Techniques for stabilization of the submerged sea cage

An illustration of a submerged sea cage is shown in Figure 4. To stabilise cage at 1-2 meters depth, certain number of floats, buoyancies, is connected to each cage, depending of the total weight, The content (water or air) of all compartments in rings shall be the same. Tilting of cage can occur in case of imbalance between compartments.

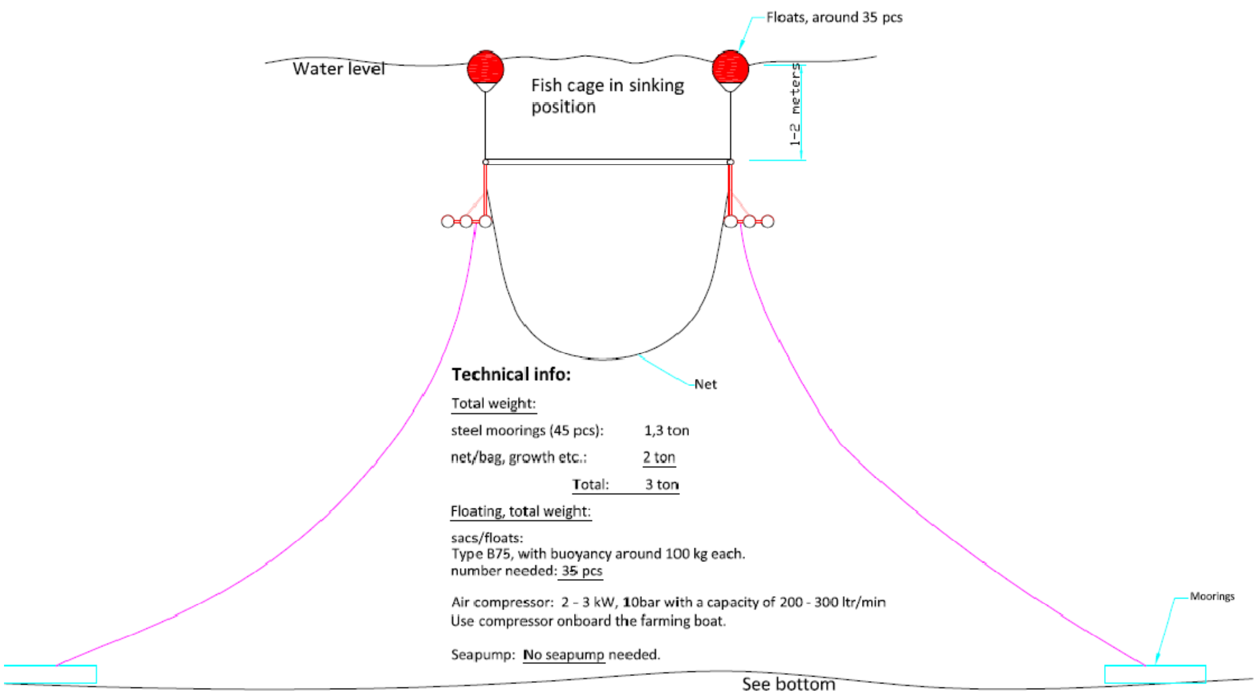


Figure 4. A sea cage in a sinking position.

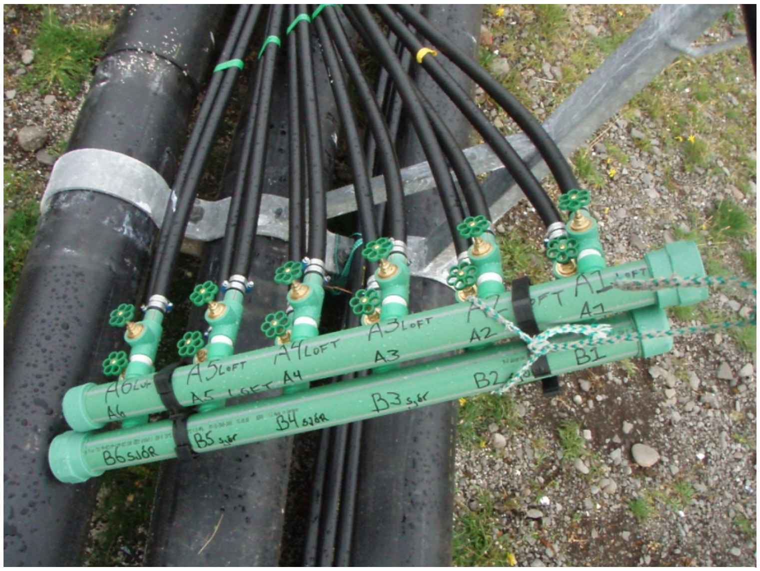


Figure 5 valves; Inlets, outlets to sink/lift the sea cage

1.1.5 Conclusion of WP 1 Task 1.2

Development of comprehensive mechanism to sink and hoist, fish cages, fast and safely under Icelandic conditions was successful by modification on the cages previously used by Hraðfrystihúsið Gunnvör in Hnífsdalur, one of the participants in the project.

1.1.6 Task 1.2 Test efficiency of submerging and hoisting on location in Ísafjarðardjúp

The prototype of modified mechanism, modified fish cage, was tested in Álftafjordur, North West Iceland (66°018672N,-22°990243W) during season known for changing weather in order to test the ability to submerge the cage in different current and weather conditions. By operating the mechanism according to the procedure developed in this project, tilting the cage was avoided even at 3 cm/sec current.

Since the mechanism was modified the weather has been better than average and ice has not formed. The cage will be tested for whole year in order to test the durability of the submerging technology and observe the effects the submerging and hoisting of the cage on the fish in the cage.

1.1.7 Testing

Successful trials were made by sinking and hoisting the cage according to protocol made in collaboration of this project the procedure was as following:

1.1.8 Sinking

A good management procedure for the sinking procedure of cage, developed in this project, consist of connecting sufficient number of floats rubber buoys to the rail of cage on equal intervals, injecting equal amount of water into the compartments of the cage at equal speed, avoiding air prop formation applying load on the remote part of the cage rails while injecting water, by applying the load the sinking time was halved. Crane of ship will facilitate the sinking process.

Figure 6 Sinking cage using crane and load

1.1.9 Hoisting

When hoisting cage applying load may facilitate the hoisting procedure, stable air pressure is needed for swift hoisting.

Figure 7 Broken valve, inlets and outlets can appear to be weak points in design if precaution is not taken while handling a cage

1.1.10 Conclusions of testing:

Capacity of pump/air compressor need to be compliable to the size of the cage which is being operated i.e. volume in compartments, mass of cage, it content and accessories may affect the sinking time. Diameter of valves affects sinking and hoisting time. Valves need to be handled with care.

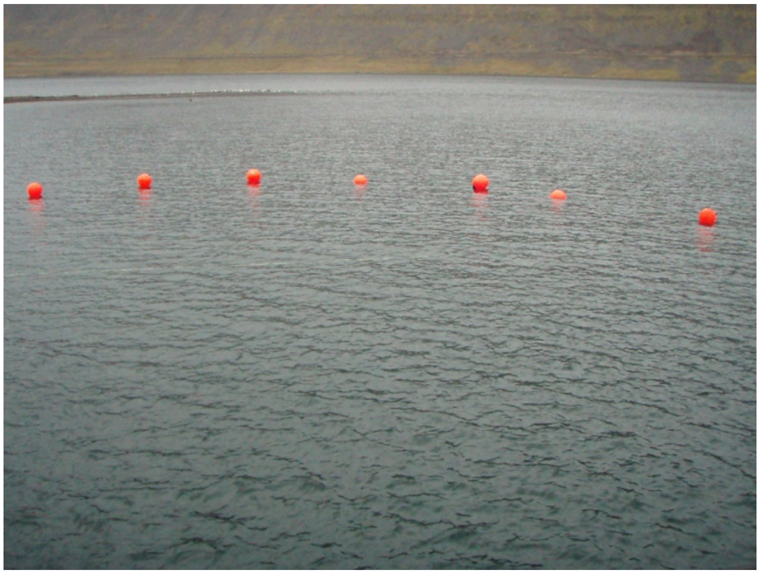


Figure 8 floats of submerged sea cage

1.2 WP 2 Net

1.2.1 Introduction

Various nets are applicable to sea cages, in order to find the best material and best suitable treatment of net, comparison trial of 3 net materials and 4 impregnations was made where condition of Net bags was compared after 51 weeks on location to measure different effect of impregnations on bio fouling of Net bags. Biofouling occurs when biomass piles up on the nets, cloaking the nets and reduces normal flow of fresh sea water

1.2.2 Net types and impregnations

Following combinations of net types and impregnations were tested in the experimental cages of Matis at Álftafjordur, North West Iceland. Nets were: Redline (polyethylene), nylon or dyneema. Treatments are: byotrol (D1), Lago 45 (common in Blue within and herring trawls), copper coating or no treatment as explained in Table 1.

Table 1. Material type of nets and treatments.

Combination	Net Bag	Material of net	Treatment	Coating
1	1	Redline (Polyethylene)	1	No Treatment (Control)
2	1	Redline (Polyethylene)	2	Byotrol (D1)
3	2	Nylon	1	Byotrol (D1)
4	2	Nylon	2	Malecite green(with copper)*
5	3**	Dyneema	1	Byotrol (D1)
6	3**	Dyneema	2	Byotrol (D1) + Lago 45
7	3**	Dyneema	3	Lago 45

.[1]:

Observations:

- Degree of bio fouling was estimated by its cover.
- The cleaning time of 1m^2 of nets from each combination was observed and compared in context of difference of treatment.

2 Methodology

1) Pictures were taken on 1 m, 2.5 m and 5.5 m different depths of same size area in each combination (Figure 13).

2) Samples for bio fouling on nets estimation taken from each combination (0.04 m^2 frame (20cm*20cm) at depths of 1 and 5.5 m after 40 weeks on location and at depths of 1, 2.5 and 5.5 m after 51 weeks on location. During the trial after 40 weeks the net was scraped for 2 minutes and all bio mass was collected in bucket located beneath the sampling (Figure 14-15).

Figure 9. Researchers taking underwater pictures maneuvered

*Traditionally impregnated with Malecite green (with copper) from Fjarðanet in Reyðarfjörður, the most commonly used coating on sea cages in Iceland
**Net bag 3 was removed before the final check (see chapter 4.1)

At the end of the trial (after 51 weeks) $0.04m^2$ area was cut out (Figure 16-17). After the sampling, the net bags were lifted on board a boat. Biomass from each net bag was collected (Figure 18). Cleaning time of $1m^2$ from each combination was observed (Figure 19).

Biofouling of each frame, was recorded prior to scraping or cutting were conducted. Animals and algae larger than 500µm in 8% formalin were grouped with Sterioscope (Leica MZ 6 and MX 12). Algae and Hydrozoa were dried shortly and weighted. For this preliminary report results are ready for station A and B of Net bag 2 in June 2010. Other samples are being processed.






3 Results from WP 2 Nets

Visual difference was observed on treatments in Net bag 2 but not on Net bag 1. Unfortunately some misunderstanding lead to the unfortunate incident that Net Bag 3 was removed prior to sampling.

Underwater pictures revealed difference in bio fouling between copper coating and Byotrol coating on Nylon net, Net bag 2 (Figure 20).

Pictures 20-25 were taken in June of 2010 in the first field trip of WP 2.

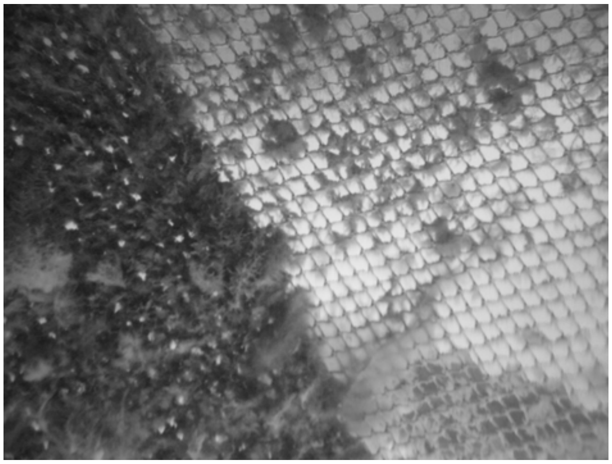


Figure 16. Net bag 2 with Byotrol on the left and copper coating on the right.

3.1 Net bag 1

Figure 17. Net bag 1. Biofouling on the net bag.

Figure 18. Net bag 1. Nudibranch (sea slug) and eggs on the net.

3.2 Net bag 2

Figure 19. Net bag 2. On the left with side treated Byotrol and on the right with copper.

Figure 20. Net bag 2. On the left with side treated Byotrol and on the right with copper.

Net bag 2 was treated with Byotrol and Copper. As can be seen on figures 20 & 24-26 the difference in resistance to bio fouling is obvious, copper appears to have more resistance.

Figure 25. Net bag 2. On the left the bag is treated with Copper and on right with Byotrol.

3.3 Result, vegetation and animals

Results of visual estimation of biofouling is shown in Table 2.

Table 2. Visual estimation of biofouling by each treatment in June 2010, x= noted, xx = cover about half, xxx = full or almost full cover.

	Station	Algae and hydrozoa	Barnacle	Other invertebrats
Net bag 1				
Control	A	xx	xx	
	B	xxx	x	X
Byotrol	A	xxx	xx	
	B	xx	xx	X
Net bag 2				
Copper	A	X		
	B	X		
Byotrol	A	Xx	xx	X
	B	Xx	xx	Xx

Vegetation and animals from each sample were analysed and listed up, Observations from samples from Net bag 2, sampled in 51st week, are listed in Table 3.

Table 3. Net bag 2, 51st week. This table shows one sample from each station on copper coating and Byotrol which have been analysed. This is the total number for net bag 2.

Phylum			Copper		Byotrol	
	Class//Order/Family	Species	A	B	A	B
Cnidaria						
	Hydrozoa		x	x	x	
Nematoda			20	8	10	3
Foraminifera			1			1
Platyhelminthes						2
Mollusca						
	Bivalvia					
	Mytilidae	*Mytilus edulis*			9	1
	Gastropoda	Juvenile	22	876	24	8
	Littorinoidae	*Lacuna vinta*	2	4	6	
	Nudibranchia				8	
Annelida						
	Polychaeta					2
	Polynoidae	*Harmothoe sp.*	1	1	21	46
Arthropoda						
	Crustacea					
	Amphipoda		1	13		
		Corophium bonelli			9	2
	Gammarideae	*Gammarus ocenicus*			1	
	Isopoda					
	Copepoda		116	24	162	118
	Cirripedia					
	Balanidae	*Semibalanus balanoides*	2	4	131	16
	Insecta					
	Diptera		1			

Barnacles (*Semibalanus balanoides*) were abundant on Byotrol treated net. Same as were the bristle worms *Haremothoe sp*. It was the most common among invertebrates that dropped on the deck when the nets were lifted on board of the boat in September (week 51). The juvenile snails (Gastropoda) were too small to be indentified but some of them could have been *Lacuna vinta.* Copepods were more in number on Byotrol (Table 3).

In Table 4 algae and Hydrozoans have been weighted (wet weight) and grouped.

Table 4 Weight (g) of Hydrozoa and algae types on net bag 2.

	Species		Copper		Byotrol	
Phylum/class	Species	Station	**A**	**B**	**A**	**B**
Hydrozoa	*Cf Obelia Longissima*		2,05	x	18,02	
Algae						
Type 1	Fine thread like		8,34	16,34	37,99	72,54
Type 2	Flat algae		5,03	x	8,03	
Type 3	Flat algae, light colour		0,44			
Type 4	Thread like algae		0,07			
Type 5	Thread like algae				9,02	
Type 6	Flat algae (green algae)				17,73	

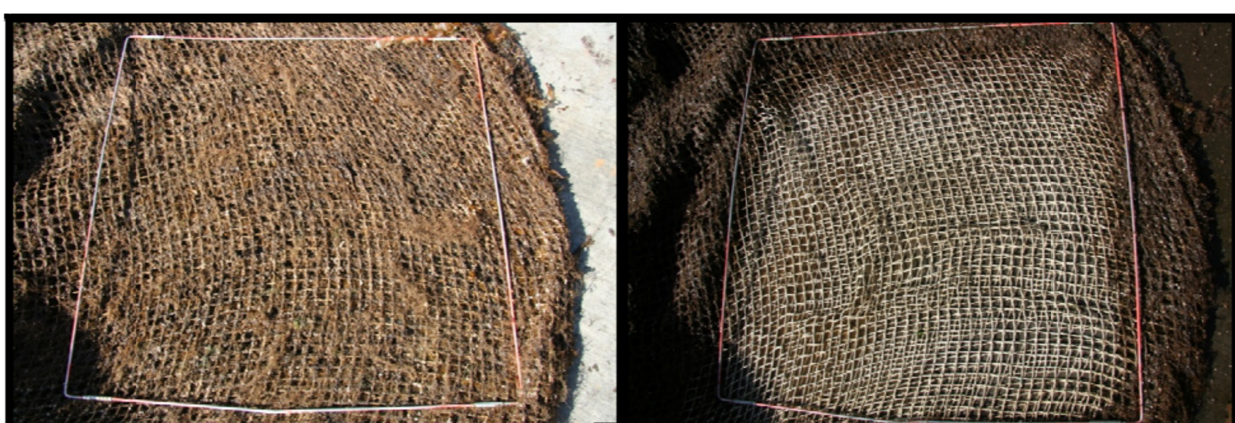
The wet weight shown in table 4 shows that the amount of algae bio fouling on the Byotrol treated material is more than the double of the copper treated nets and the amount of hydrozoa is nine time more on the Byotrol treated surface than on the copper treated surface.

Results of observations while cleaning the 1m^2 of nets at the end of the trials are shown in table 5.

Table 5. Time (sec) it takes to wash the nets (1x1 frame).

Bag	Treatment	Time sec	Comments
Net bag 1	Byotrol	50	Almost clean
Net bag 1	Control	55	Some barnacles left
Net bag 2	Copper	46	Clean
Net bag 2	Byotrol	61	Some barnacles left

In figure 26 and 27 is net bag 1, before and after washing.



4 Conclusions of WP 2 Nets

Copper coating appears to have the strongest resistance to biofouling in terms of numbers of individuals observed on Nylon net, Netbag 2, according to the current results. It should be noted that not all samples have been processed at this time. Byotrol does not appear to have same resistance as copper to algae, Hydrozoa and Barnacles.

It is known that some species of Hydrozoa can be dominant on fish farming nets in Norway and in England (Cook et al. 2006; Guenther et al. 2009). The Hydrozoa species *Obelia longissima* was found on the nets in Álftafjörður and is also found on fish farming nets in England. This Hydrozoa species is common all around Iceland (Ólafsson 1975). Copper coating benefits the fish farmer in terms of resistance of biofuouling. Never the less there are restrictions on copper usage in food processing and such restrictions might affect the possibility of using copper in coating nets in sea cages. Therefore a more sustainable method to treat the nets is highly needed.

The findings of this WP lead to more research in this area and the next steps are trying other coatings with both control and copper coating to find out if other more sustainable coating methods are in reach.

Discussion and conclusions

North Cage 2 stands for the second year of the project North Cage. The AVS fund only funds the second year of the project which is now finished but the project was funded for three years by Tækniþróunarsjóður (Technology Development Fund).

North Cage 2 has two main deliverables.

1. A sinkable sea cage technique ready to be used commercially
2. An insight into the difficulties of finding a fully competitive none copper based substitute anti fouling treatment of net bags for sea cages used in aquaculture

A technique has been developed which can be applied to any sea cage type on the market to make ordinary sea cages sinkable. Testing of the technique has showed that it functions well and the only restrictions to the sinking- and hoisting speed of the sea cage is the pumping capacity of the sea- and air pumps used.

Most aquaculture companies today in Iceland, and elsewhere, use anti fouling treatments for their net bags. This anti fouling treatment is copper based and due to that a substitute must be found and much effort is put into trying to find that substitute. Deliverable 2 is one step in that direction. It gives findings from year of testing of different anti fouling treatments of net bags in comparison to the most commonly used copper based treatment. None of the tested treatments held the fouling from the sea cages as well as the copper based one. The tested substitute, Byotrol, still gives an indication that it could be a possible substitute. That is because the product Byotrol makes the net bags softer and therefore easy to clean although the amounts of bio fouling where much higher on the Byotrol treated net bags compared to the copper based treatments.

Last but not least the project board wants to thank the Technology Development Fund and the AVS fund for their contribution for making this project possible.

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