PROJECT NO: FP6- 032788

NETWASH

NetWash- In-Situ Net Cleaning System in AquaCulture

Co-operative Research (CRAFT)

Horizontal Research Activities Involving SMEs

Final Publishable Activity Report
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Project Coordinator: Seloy Undervannservice AS Version Draft

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PROJECT INFORMATION

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COORDINATOR:	Seloy Undervannsservice AS
SME EXPLOITATION MANAGER:	Seloy Undervannservice AS

SME CONTRACTORS:

1 Seloy Undervannsservice AS ***SME***
2 Niebling Technische Bürsten GmbH ***SME***
3 BTT Automatyka Sp. zo.o. ***SME***
4 Tsurumi-Intec Pump AB ***SME***
5 Imenco Engineering AS ***SME***
6 Productos Mesa S.A. ***SME***
7 RefaMed s.r.l. ***SME***
8 Marina 2000 s.n.c ***SME***

OTHER ENTERPRISE/ENE USER CONTRACTORS:

9 Hradfrystihusid-Gunnvor hf. ***Other/End User***

RTD PERFORMER CONTRACTORS:
10 National Institute of Technology/Teknologisk Institutt as **RTD**
11 PERA Innovation **RTD**
12 Gdansk University of Technology **RTD**

PUBLISHABLE EXECUTIVE SUMMARY

Wild fish is a limited resource, and focus on sustainable development has demonstrated that increased catch of wild fish will not be the solution to increased demand for food in the world. This certainly also applies to the fishery resources in Europe. The EU commission has repeatedly underlined the weaknesses of the Common Fisheries Policy (CFP) and has in the Proposal for a Council Regulation on the conservation and sustainable exploitation of fisheries resources recommended several actions including reduction of fishing capacity, reduced access to waters and resources as well as an enforcement system. The overall effect of this is reduction on the catch of wild fish. Aquaculture represents a solution by ensuring a supply of fish products without increasing the pressure on wild stocks. In addition, aquaculture has already provided - and has a further potential in the future to provide - alternative employment in many fisheries dependant regions in Europe.

Aquaculture has played a significant role in the improvement of the socio-economic situation in the coastal communities and the overall framework shows a positive development. Nonetheless, European aquaculture still experiences a number of problems. In particular, as aquaculture expands there is a considerable concern with respect to the sector as representing a threat to ecology due to risk of pollution, eutrophication, etc. One of the strongest concerns regarding the pollution aspect has recently been the anti-fouling treatment of nets to avoid natural occurring fouling. Especially, this has been under debate in relation to discharge from central net washing sites as potential harmful anti-fouling chemicals - such as copper oxides - are removed from the nets during cleaning and discharged with the effluent water from the process. As a consequence, in terms of reducing discharge of pollutants from such activity, the Norwegian government has introduced a new legislation put into force in spring 2004 (Forurensningsforskriften) which prevents discharge of environmentally harmful chemicals related to the activity of cleaning, washing and impregnation of nets in fish farming . This legislation is not, however, valid to such activity being performed in-situ on site, revealing that the concern is related to the concentration of discharge of such chemicals rather than the chemicals themselves, actually being naturally abundant in the environment.

From the fish farmer’s point of view, one of the greatest headaches in daily husbandry is net fouling (see example of net fouling in Figure 1). Fouling is the growth of unwanted flora or fauna on the netting. The ensuing clogging of the meshes impedes the passage of water through the cage, and this reduction in water exchange, combined with the metabolism of the fish, can result in depleted oxygen levels and elevated ammonia levels, which reduces animal health, and increases levels of fish mortality, certainly unwanted features for the fish farmer. Heavy fouling can also increase current-induced drag forces on all submerged equipment, potentially resulting in gear failure, because of overloading. In many fish farming sites, particularly during late spring, summer and early autumn, a cage can become almost completely clogged with an assortment of algae, hydroids, and mussels within three to four weeks. Fouling is a particular problem inshore because of the proximity to shorelines and reefs where the spores and larvae of fouling organisms originate. Offshore sites are less prone to fouling; however, if the fouling organisms are allowed to develop on even one cage, they can quickly spread to adjacent cages. Once fouling becomes established at a site it can be difficult to manage, particularly at

times of high water temperature. Normal methods of control include changing the nets at frequent intervals, diver or surface operated power washing and the use of anti-fouling paint. Anti-fouling paint is expensive and in warmer water areas only gives a few weeks grace to a net before it has to be washed or changed again. This makes its use on the biggest fish farming nets almost pointless because these can normally only be changed after harvest, when they are empty. Worldwide, in-situ washing of cage nets is probably most often done by the use of divers. This exercise is expensive and presents significant health and safety considerations, especially where deep nets are used.

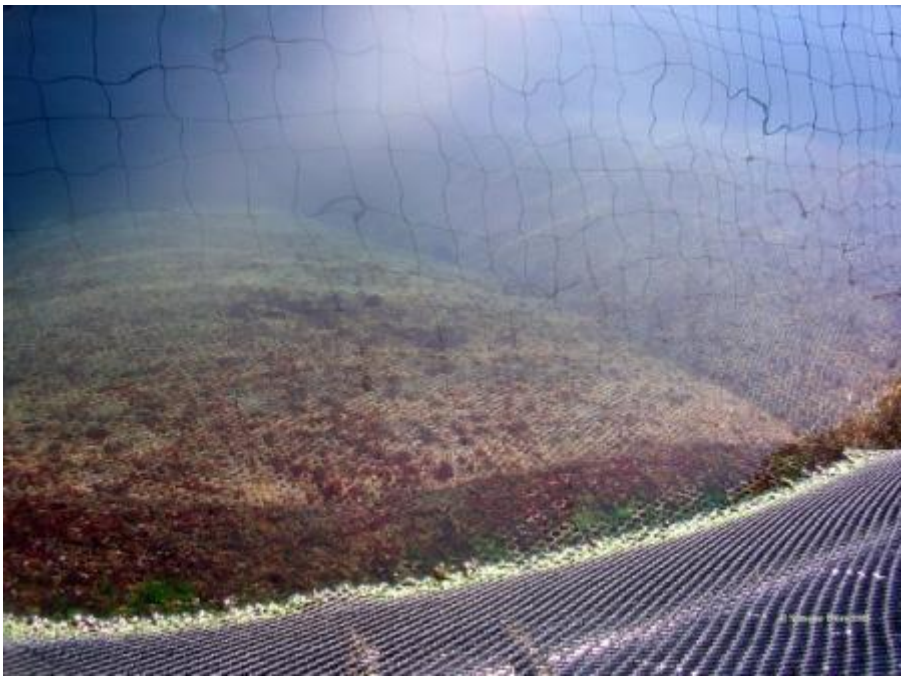


Figure 1 - Example of net fouling

The report: “Farming the deep blue” jointly commissioned by BIM (The Irish Sea Fisheries Board) and the Irish Marine Institute assess the potential for further development of offshore fish farming of finfish internationally. The report was also produced to coincide with an international conference held in Ireland in October 2004 entitled “Farming the Deep Blue” organized by BIM. Both the report and the conference concluded: “The development of a specialist robotic net-cleaning system would be an attractive commercial proposition even now, as the inshore industry badly needs such equipment”.

With regards to cleaning of fish farming nets, which have continuously throughout the years become larger and deeper, it must be assumed that access to the net by use of traditional solutions, i.e. ropes and poles, will often be difficult if not impossible in future fish farming systems. Highly specialized, remote control and monitoring capabilities must therefore be a major feature of the net cleaning operation methodology.

The “NetWash” project focuses on the development of a cost effective, easy to operate net cleaning device for use on fish farming sites that can be remotely operated without the need of divers. Remote operation without the costs related neither to divers nor to the change or impregnation of nets, transportation of the nets

and net washing at a central net washing site, encourages avoiding expensive and environmentally questionable use of anti-fouling chemicals, thereby contributing to environmental and economical sustainability in aquaculture and to an improved reputation about the sector.

A number of novel approaches have been suggested for cleaning of nets in water. One suggestion envisages using wave action to create constant movement of brushes suspended from surface floats to clean the cages. Another solution would be to employ submarine robots to patrol and clean the cage net on a continuous basis with the use of brushes or water jets. Our idea is somewhat different than the ideas already suggested, as our approach is to develop a specially designed vehicle, which uses thrusters for movement. The washing, or cleaning technology itself, is based on the combination of brushes and water suction rather than water jets, setting up water current through the net mesh, which flushes off any fouling organisms that the brushes tend to rip off. The advantage of the suction technology over other approaches or existing solutions is that by our proposed technology, this enables to collect – or move the fouling organisms away from the fish pen or fish farm as a whole – thereby increasing physical water environment for the fish and for the simultaneous net inspection. This may also have impact related to potential eutrophication in shallow fjords and bays. Our net cleaning device will be equipped with camera for simultaneous net inspection purposes. The vehicle will have an umbilical tether for control and camera signals.

The commercial partners involved for the project duration are:

Norwegian **Seloy Undervannsservice AS** – supplies products and services for sub-sea and marine applications
German **Niebling Technische Bürsten GmbH** - development and manufacturing of customized brushes for technical use
Polish **BTT Automatyka Sp. zo.o.** – manufacturer of industrial automation of underwater systems
Swedish **Tsurumi-Intec Pump AB** – supplier and provider of expertise for pumps and pump installations
Norwegian **Imenco Engineering AS** – offers engineering and equipment services and repair, expertise on ROV sub-systems and ROV-technology
Spanish **Productos Mesa S.A.**- manufacturer of hoses and tubes
Italian **RefaMed s.r.l**.- producer and supplier of nets for the fish farming industry, including supply of service of nets
Italian **Marina 2000 s.n.c** – producer of marine finfish

OTHER ENTERPRISE/END USER CONTRACTORS:

Icelandic **Hradfrystihusid-Gunnvor hf**. – Fish farming of Atlantic cod

RTD PERFORMER CONTRACTORS:
Norwegian **National Institute of Technology/Teknologisk Institutt as**
British **PERA Innovation**
Polish **Gdansk University of Technology**

SECTION 1 – PROJECT OBJECTIVES AND MAJOR ACHIEVEMENTS

1.1 Overview of General Project Objectives

Scientific Objectives

The Scientific Objectives of our project are to create:

- **Enhanced scientific understanding on fouling issues.** To create a detailed overview of variances related to fouling species, attachment forces, and total amount of fouling material. These variances will be related to cold- and warm & temperate water areas.
- **Enhanced knowledge on material technology related to the marine environment.** To create enhanced understanding about suitable materials that can be used - and how they can be used - in relation to properties, durability and corrosion.
- **Enhanced knowledge about possible control systems** for sub-parts and the complete NetWash system.
- **Enhanced understanding and specification of effects from external factors on submerged device.** Evaluate external forces of loads on device during cleaning due to currents, weights etc. in relation to buoyancy control and movement.

Technological Objectives

The overall technological aim is the development of a cost effective net cleaning submersible device that is remotely operated and controlled with an umbilical tether from above sea surface. The device will be integrated with brushes and water suction sub-units for cleaning of net, camera & illumination equipment for controlling and net inspection purposes, and thrusters for movement. The specific technological objectives of our work are to:

- **develop an in-situ net cleaner** with the capacity to handle 800 m^2 netting per hour
- **reduce fouling on the net to ≤ 5%,** i.e. reduction of > 95% by wet weight (As we foresee major problems related to ensuring complete (100%) cleaning effect due to adherence of special well attached organisms like certain bivalves and cirripedias, our objective is to reduce at least 95% of the total fouling by weight compared to reference nylon netting commonly used in the sector).
- **create water current through the netting of 10.2 m/s**, set up by a suction mouth with a slit, 50cm wide (related to efficiency & first bullet point)
- **operate the complete vehicle by energy consumption < 4.7 kW**
- **create the device for possible use down to 40m below surface (altered to 10 for Netwash prototype)**
  - Required development and use of waterproof sub-units
- **use the water current generated by the main pump system to power brushes** mounted in front of the suction mouth, **enabling rotation speed ≤ 360rpm**
- **to enable the cleaning of net structures at any sloping**

- **develop a control system for vehicle management** closely linked to the monitoring of submerged surroundings and net cleaning efficiency by use of integrated camera and illumination system.

1.2 Project Objectives and Achievements

The specific objectives for the thirty-month period of 1st of October 2006 to 31st of March 2009 of the project are summarized in the table below.

Deliverable No	Task	Partners Involved	Objective	Achievements During Reporting Period
1.1	1.1 1.2 1.3	Seloy Niebling Marina 2000 Hg Hf TI PERA GUT	Report with detailed description of the requirements of the foreseen NetWash system, especially on technical requirements of camera, buoyancy control system, and ROV control, based on the loads and forces influencing on submerged vehicle.	Completed – a report (D1.1) which discusses fouling issues and external forces acting on the submerged device in detail
2.1	2.1 2.2 2.3 2.4	Seloy Niebling Tsurumi Imenco ProdMesa Marina 2000 Hg Hf TI PERA GUT	Prototype of suction mouth with integrated brushes and adjustable pump system.	Completed – a prototype of a HP net washer has been designed. Brushes for the HP net washer have been manufactured Power system has been selected Nozzles have been tested for optimal thrust and power requirements Optimal piping was selected
3.1	3.1	Seloy Marina 2000 HG hf GUT	Design and development of housing shell	The Netwash prototype housing shell has been worked on by GUT for the GUT prototype, the TI prototype has an aluminium frame to hold the brushes but no plastic housing
3.2	3.2	Seloy Imenco	Choice and testing of camera and illumination	Camera and illumination

		Refamed Marina 2000 HG hf TI GUT	technology	technology from Imenco has been chosen, integrated and tested
4.1	4.1 4.2 4.3	Seloy Tsurumi Pera GUT	Report on control system for brushes rotation speed and suction water flux and buoyancy and movement by thrusters	The report on control system has been completed
5.1	5.1	Seloy BTT Tsurumi Imenco TI	Integrated prototype	The integrated prototype has been integrated and tested and is presented by video as well as photographs and description available in the report for D5.1
5.2	5.2	Seloy BTT Tsurumi Imenco TI	An evaluation report on the performance of the complete and integrated netwash technology	The validation of the Netwash technology has been completed through a series of testing at Norsk Havbrukssenter in Brønnøysund, Norway
5.3	5.2	Seloy BTT Tsurumi Imenco ProdMesa RefaMed Marina 2000 HG hf TI Pera GUT	Validation of the commercial viability of the technology application, including feature benefits and cost implications by representatives of the target market-sectors, i.e. the end-users.	The commercial viability of the technology application has been detailed in the report following D5.3
6.1	6.1	Seloy BTT Imenco RefaMed TI Pera GUT	Report on potentially competitive patents and a plan for patent applications if required with exploitation agreements between partners.	A report on potentially competitive patents has been written, D6.1
6.2	6.2	All partners	Two papers presented at 4 conferences and major exhibitions and two	Netwash has been presented at AquaNor 2007 and

			publications in the form of editorials, technical papers or trade press	Aquaculture Europe 2008.
7.1	7.1	Seloy BTT RefaMed	Dissemination and Use Plan, DUP	The final version of the DUP has been completed.
7.2	7.1-7.6	Seloy Niebling Tsurumi Imenco ProdMesa RefaMed Marina2000 Hg Hf	Mid-term management meeting to review progress against objectives and plan future work. Draft DUP presentation.	Completed
7.3	7.2	Seloy Marina 2000 HG hf	Publishable final report	Completed

SECTION 2 – WORK PACKAGE PROGRESS

2.1 Work package objectives

The specific work package objectives for the 18month period of 1st of October 2007 to 31st of March 2009 are shown below.

Work Package No	Work Package Title	Lead Contractor Short Name	Person Months	Start Month	End Month	Deliverable No
1	Enhanced Scientific Understanding	TI	16,0	1	6	D1.1
2	Development of an Innovative Net Cleaning "Mouth"	GUT	18,6	5	10	D2.1
3	Development of Housing	BTT	19,6	8	14	D3.1 D3.2
4	Control System	PERA	12,8	8	16	D4.1
5	System Integration and Industrial Validation	TI	19,5	13	30	D5.1 D5.2 D5.3
6	Innovation Related Activities	Seloy	9,0	1	30	D6.1 D6.2
7	Consortium Management	Seloy	3,3	1	30	D7.1 D7.2 D7.3
8	Project Management	Seloy	12,6	1	30	
	TOTAL		111,4			

2.2 Overview of work package technical progress

Work package 1 Enhanced Scientific Understanding

Objectives:
To create a detailed overview of issues regarding fouling, material technology and external influences and loads. These parameters include variances in fouling species, attachment forces, and total amount of fouling material. These variances will be related to cold- and warm water areas. Further to create the knowledge about suitable materials that can be used - and how they can be used - in relation to properties, durability and corrosion. Evaluate external forces of loads on device during cleaning due to currents, weights of cables, hoses, brushes etc., in relation to buoyancy control and movement.

Progress:
A detailed scientific report has been produced dealing with mainly the 3 issues:

- Fouling issues
- Suitable materials for the NetWash system
- External forces on system

Deliverable report D1.1 contains the detailed results.

Furthermore TI has in collaboration with the SME partner RefaMed placed out frames to monitor the fouling conditions in Mediterranean waters at their location on the south tip of Sardinia.

Work package 2 Development of an Innovative Net Cleaning "Mouth"

Objectives:
The development of suction "mouth" with integrated rotating brushes in front, driven by the water suction flow provided by above surface pump. The mouth should have the ability to strip off fouling organisms from the net, effectuated through the influence from the suction water flow and the brushes in combination. The technology should raise the fouling organic matter to above surface level and leave no material for sea-water turbidity generation. There should be minimal influence on the netting like wearing etc.

Progress:
A prototype of a High Pressure (HP) net washer has been designed. Brushes for the HP net washer have been manufactured, power system has been selected, nozzles have been tested for optimal thrust and power requirements and optimal piping was selected. The final manufacturing of the prototype has been delayed according to the plan due to delayed delivery of the Janus hydraulic motor. The proposed tests have therefore not yet been run following the original plan. We expect the motor to arrive and the test to begin by week 21

Deliverable report D2.1 contains the detailed results.

Work package 3 Development of Housing

Objectives:

The development of a housing for the suction mouth developed in WP2 with incorporated camera and lighting for cleaning and netting inspection, buoyancy control system and thrusters for movement. The device should give the possibilities for the positioning of the cleaning mouth in all possible angles, applicable for use in cage systems with sloping nets.

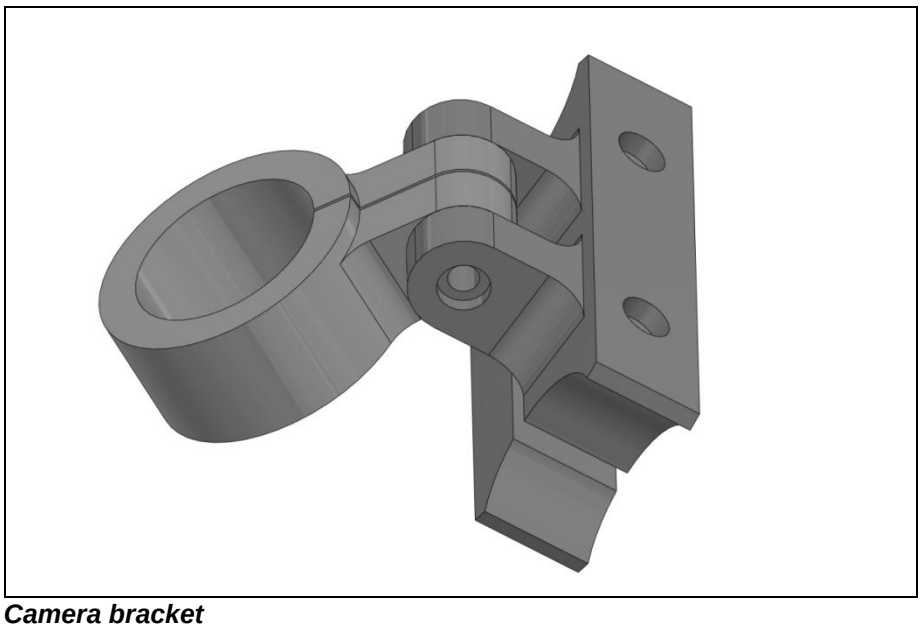
Progress:

WP3 has been completed. The housing has been molded at GUT in Poland. The GUT prototype experienced problems among others shrinking of the housing and entanglement of net in brushes. Due to the lack of progress the consortium decided to work on a second prototype at TI. This prototype has gone through two versions and has been tested with integrated camera and lighting.

Camera for TI prototype

The camera used was supplied by consortium partner Imenco and modifications to suit the Netwash system was performed by TI. The TI Electronics Department made some modifications to the supplied camera in order for it to fit with the Netwash system. The original cable was exchanged for a lighter and shorter one to save weight and to get a more flexible cable, as the NetWash unit is manually handled at this stage to a shallower depth. In addition, a 12V DC power supply was connected to the camera.

A Universal TV Tuner from TERRATEC (CINERGY HTC USB XS HD) was connected to the coax cable from the camera and a lap-top computer. Software from WinAVI was then installed on the lap-top, to enable good quality pictures to be obtained using the camera and also to capture film to the hard drive continually.



Camera bracket

GUT work

The GUT activity was devoted to:

1. Procurement and evaluation of effectiveness of ejector concept pumping device.
2. Procurement and experimental evaluation of operations of the brush equipped washing mouth in contact with a net

The basic concept of the injector type pump assumes that water with dirt removed from a net by the action of the washer brushes will be sucked out from the washing mouth and transported to a surface facility by means of high pressure water stream. Basic advantage of the concept is lack of any moving parts and extremely low weight. The same medium (high pressure water) is used for this purpose as well as for control of the vehicle movement by means of nozzles and for brush propulsion.

The tests performed to date indicate the complexity of the problem. The pumping effect was visible but achieved flow rate far below expectations.
The results are summarized non fig. 22 and fig 23 where:

- R – ejector without nozzle (clear pipe).
- D=40 – ejector with nozzle D = 40 mm;
- D=20 – ejector with nozzle D = 20 mm;
- D1 – HP supply nozzle with additional nozzle D1;

As can be seen application of the thin water jet without Venturi nozzle is not effective. The pressure generated is to low to give the water flow. Introduction of the nozzle increases the pressure and generated flow. However, effectiveness is very low. Reduction of the nozzle diameter to 20 mm gives some increase of the parameters but both pressure and output flow rate remain below requirements. The flow rate is 25% of required flow of 16 l/s that was assumed to be minimum for the application
The results indicate possibilities to achieve required values od flow but requires further multiparameter optimisation. This requires return to the computer simulation the reduce costs and time of optimisation.

GUT prototype

Following negative results of experiments with the size M6 on prototype No 2, motor the size M30 was acquired. The prototype No 3 of the mouth was built using the same material (PE). The size M30 motor has been integrated with gears and brushes that were available before and mounted to the mouth body. The body was widened to adopt brushes without coincidence of whiskers during operation. To balance the substantial weight of the motor 10 kg of lead weight was added on the mouth side opposite to the motor (fig. 25)

The prototypes no1 and 2 of the mouth body adjusted to different brush sizes

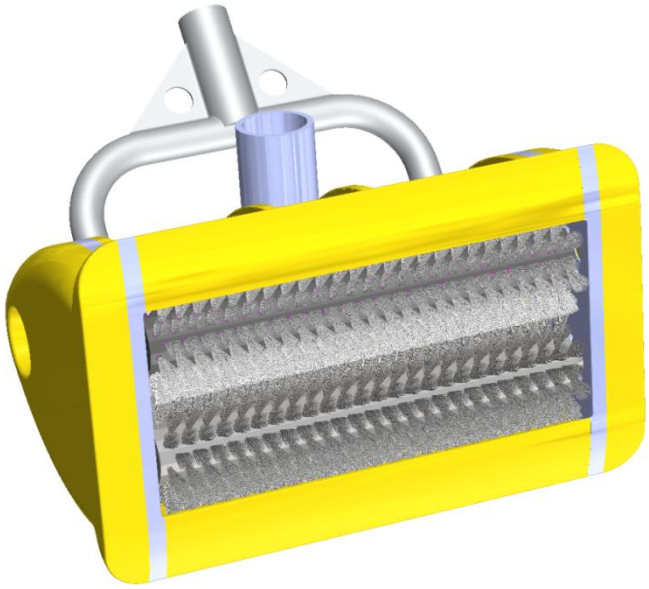
The test of the mouth prototype No 3 were performed in experimental tank using a net stretched on the aluminium frame. The frame with the net was lowered to working brushes horizontally. This allowed for control of the pressing force and visual observation of component performance.
The results are as follows:

- The No 3 washing mouth prototype works satisfactory. It operates smoothly without stops. The rotation speed can be easy controlled be throttling of water supply. It offers substantial reserve of the torque.
- While operating net gets entangled (fig. 29), regardless rotation direction (both inward and outward) of the brushes.
- Initial problems with net entanglement were solved by application of a separation wires as can be seen on fig 30.The separation wires were made of stainless steel spring wire 0,6 mm thick. They are not affecting brush operation at all.
-

The mouth with wires works very satisfactory. The weight of the motor and compensation ballast seems to be acceptable in considered conditions. The mouth washing effectiveness needs to be tested at real conditions of a fish farm.

TI prototype

In June 2008 a design for a new version of the Netwash prototype was drawn up. This was designed to be made of plastic materials, as suggested earlier by GUT. One of the reasons for this was the buoyancy of the material in addition to production price. The design was based on two brushes rotating away from each other on the front. This was to avoid capture of the net, with the following destruction of the net by the brushes. Also the housing shape was designed to take advantage of the brushes ability to help pushing the water backwards and up the pipe. At this stage the unit was planned to be used down to fifty meters, and with the waste from the cleaning process to be taken up to the surface. A venturi pump was planned to be used close to the NetWash unit, pushing the waste up to the surface.



This 3D drawing shows the first prototype seen from the front. The housing got a smooth and rounded surface on the front, to avoid destruction of the net. An aluminum handling frame is seen in the back.

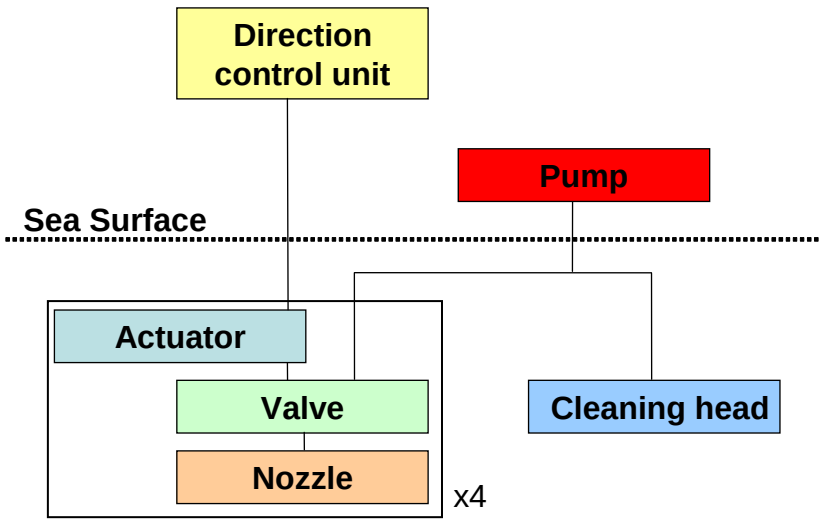
Work package 4 Control System

Objectives:

The development of a control system for the complete netwash device. To obtain optimal control and cleaning efficiency of nets in-situ by using clear visual impressions from camera system via monitor above sea-level to manage features like brushing and water flow through adjustable intensity and capacity, respectively, rendered possible by intelligent and easy buoyancy control and thruster navigation.

Progress:

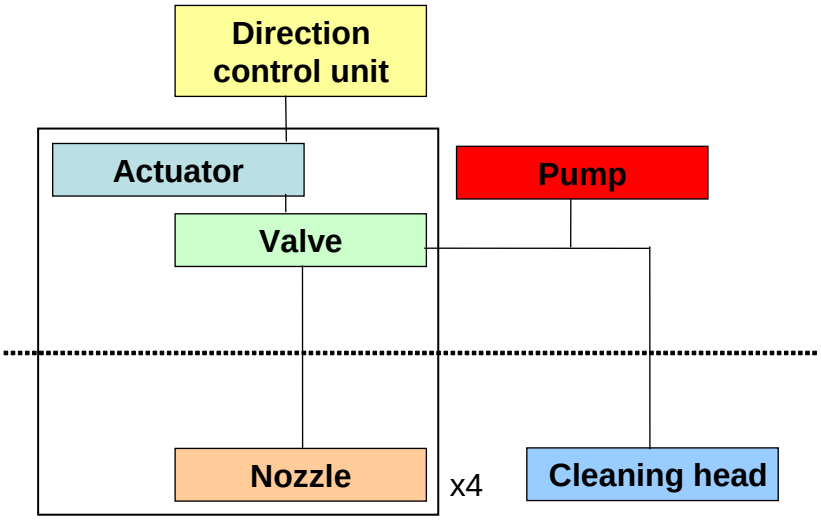
In order to control the NetWash cleaning unit, a control system is needed. As has already been discussed in Task 1.2 (WP1), the original plan for the control system was based on the following design:



Schematic of Control System. Movement of the control lever on the direction control unit operates actuators, opening valves that are supplied by a high-pressure pump and allowing directional movement of the rig

The direction of the cleaning unit was to be controlled using remotely-operated actuators built in. A high pressure pump on the service boat would feed water to the unit along a single high-pressure pipe. To control the direction of the unit, valves would be opened by the actuators allowing high-pressure water to be ejected from nozzles developed by GUT, propelling the unit in the opposite direction. In this layout, movement and cleaning operations could all be carried out using the same high-pressure water feed, leading to significant design simplification. In addition, the only electronic control required would be the activation of the actuators, as control of the cleaning brush speed would be achieved by variation of the water flow from the high-pressure pump on board the service boat.

After some tests and discussions, it was decided that the following set-up would be a more suitable system for Netwash:



Revised schematic of control system. Movement of the control lever on the direction control unit operates actuators above sea level, opening valves that supply high-pressure water to nozzles attached to the sub-sea ROV

By placing the actuator and valve assembly above water, maintenance of the system would become much easier and problems with sub-sea operation would be overcome. In this design, instead of having one high-pressure water hose connected to the unit, four hoses would now be required that would each supply water to one nozzle. This was not perceived to be a problem within the consortium. It is believed

that the extra pipes will also help with buoyancy, keeping the head of the cleaning unit horizontal.

It was determined that the best way to monitor brush rotation speed was to use a digital pulse generator that measures the rotation speed of the hydro motor drive electromagnetically and sends a signal back to the control unit. This signal can be interpreted by the main unit, converted back into a rotation speed and displayed on a digital display so that the unit operator can accurately control the brush rotation speed by adjustment of the water flow rate. The system is controlled by an operation unit, which itself is attached to the main unit. Commands given by the operator into the operation unit are transferred to the main unit where the inputs are processed. The main unit can control the operation of the camera and lights, the speed of rotation of the cleaning brushes (by altering the water input pressure to the brush drive system) and the opening and closing of the valves that control water flow to the directional thrusters. The main unit also controls the system lift, which changes the depth of the unit.

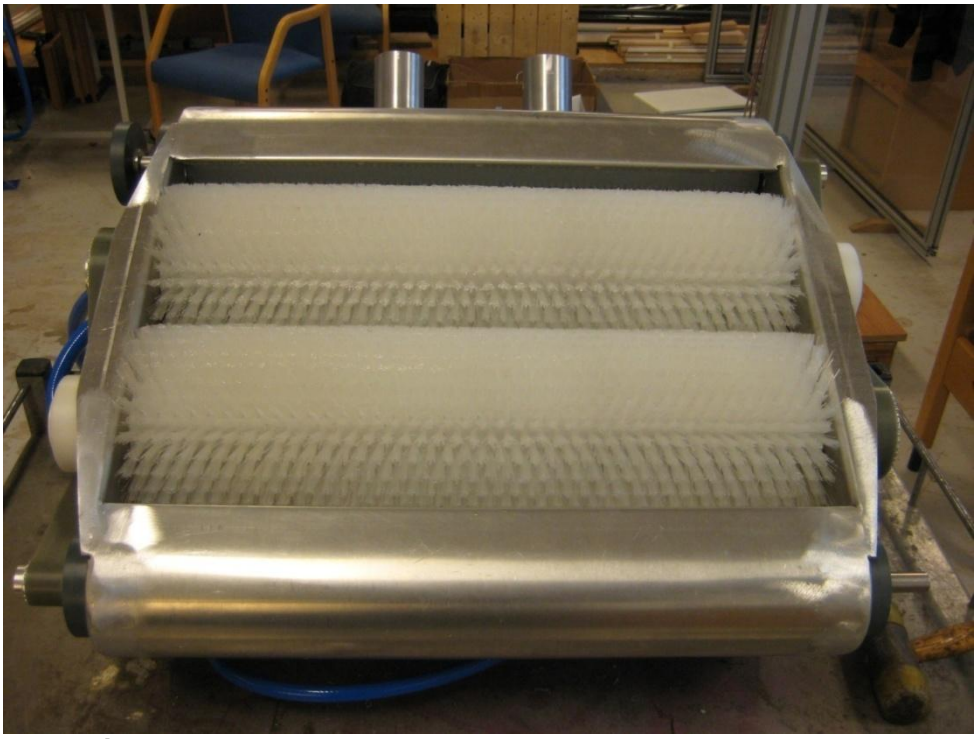
Work package 5 System Integration and Industrial Validation

Objectives:
Integration of the sub-parts in order to obtain a fully functional NetWash system. Validation of the NetWash technology by demonstration of the fully integrated net cleaning system against industrial objectives.

Progress:

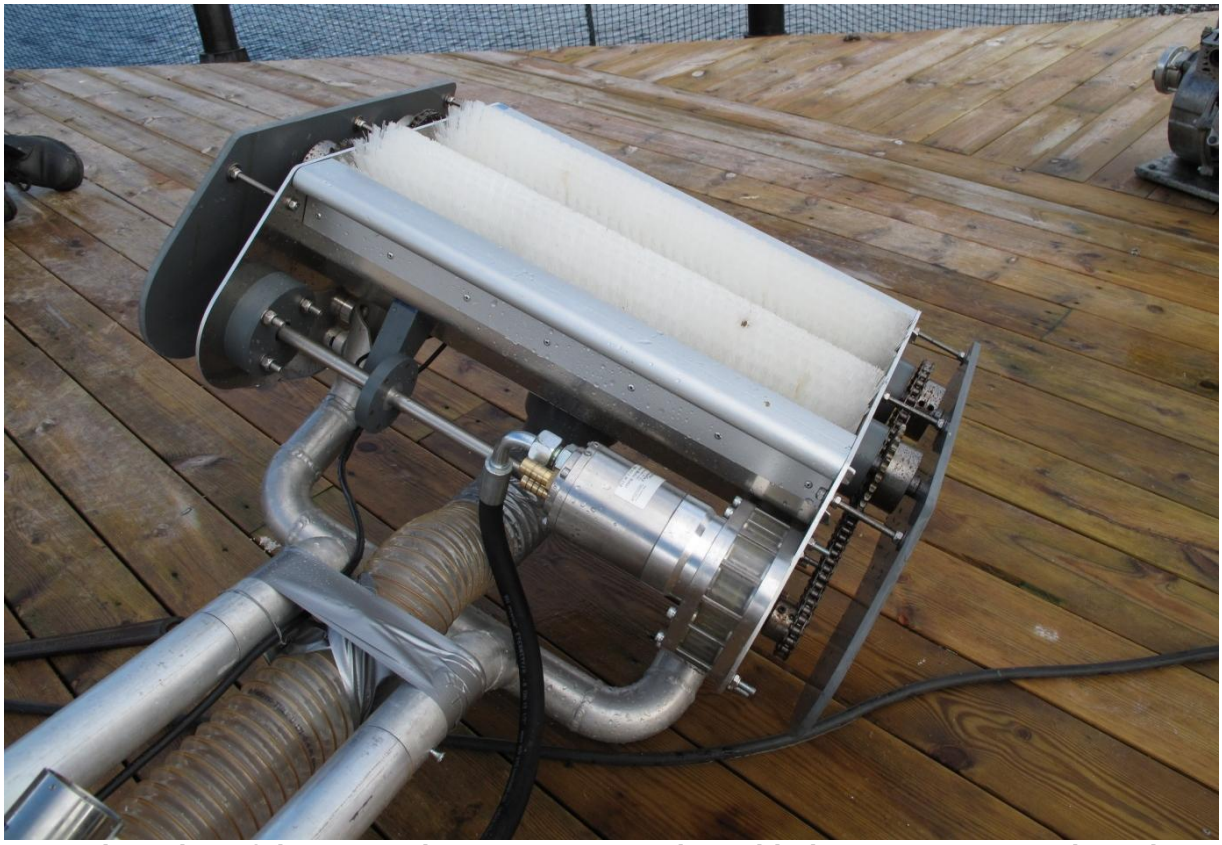
The TI prototype was designed after meetings with GUT and Niebling. This prototype is different than the GUT prototype in that it has two brushes and does not contain nozzles. This means that it cannot be positioned during cleaning operation. This functionality will be integrated post-project.

The first version of the TI prototype with handling frame, see below.



Front view.

The first prototype was tested at Norsk Havbrukssenter in Brønnøysund, Norway. After the initial tests of the first version of the Netwash prototype it became clear that some modification would benefit the functionality of the washer. Therefore, further work was done which resulted in the second version of the prototype presented below.



Second version of the Netwash prototype. Top view with the water motor and gearbox in center

Tests of the Netwash cleaning unit has been performed at Norsk Havbrukssenter in Brønnøysund, Norway. The first tests were performed on the first and second day of December 2008 and the second set of tests in March 2009.

Figure 1 Norsk Havbrukssenter, Brønnøysund

The location suited the needs of the Netwash project perfectly and the TI representatives got valuable support from the Managing Director of Norsk Havbrukssenter, Arnfinn Torgnes and his colleagues.

On the first day of testing we were able to get the wanted speed of 300 rpm on the brushes as they were submerged. The second day however, the temperature was too low and the engines froze in seconds/minutes after they were started. The reason for this was that there was no water on the airline from the compressor, and the moisture level in the air got too high. Therefore, in just a short time, motor froze solid.

In regard to suction, the Honda pump could have had more power, preferably about double the size. The pump house had to be filled with water every time that the system was started. Further tests should therefore use a water jet combo, or water jet alone.
The first trials at Norsk Havbrukssenter mainly gave valuable knowledge in the function of the prototype in the sea. It was confirmed that this design gives sufficient speed of the brushes but also indicated that some modifications were needed. Trails were made difficult by the motor freezing due to the weather conditions and also due to the fact the net on which trials were performed was not equipped with weights (as the net normally is), making it difficult for the brushes to get good contact. All of these experiences were taken into consideration at finalization of the second version of the prototype.

The second version of the Netwash prototype is different from the first version in the following:

- Equipped with camera and lighting supplied by Imenco
- Equipped with water engine power supply
- Modification to brushes

The pictures below are from the testing of the second TI prototype performed March 16th-17th 2009. The TI representatives got valuable assistance from Norsk Havbrukssenter and instead of a compressor giving power to the Netwash unit a large high pressure washer was used. Also, the same Honda pump as for the first test was used.

Netwash unit idling with the exoust water flowing out of the engine, and to the left. Camera visible down at the right side.

It is evident from the testing performed that the Netwash device works for cleaning the net. The camera and lighting system works well. The device shows great promise and was regarded with much interest from the personnel at Norsk Havbrukssenter who are interested to be involved further on in the developments of the Netwash unit. The integration of a finalized control system remains as do the implementation of remote operation and integration of waste collection. As the project got delayed by the lack of progress in the work by GUT, all functionalities have not been finalized. However, the principle of the design has been proved and work will go on post-project.

Work package 6 Innovation Related Activities

Objectives:

Project results formulated and compiled into a protectable form included patents. Develop an Exploitation Strategy, a Consortium Agreement signed between the partners and protection of Intellectual property rights arising from the technological developments in the project. Promotion of Netwash technology to 120 fish farming companies and other service providing companies in the Aquaculture sector through the networks of industrial contacts through trade press, regional clusters, chambers of commerce networks, websites etc. Disseminating knowledge and benefits of the new in-situ net cleaning technology websites and distribution of CD ROMS and DVDs. Disseminating knowledge & benefits of the new in-situ net cleaning technology at 5 conferences and workshop events with a target of 150 attendees. Presentation of the concept at trade or sector specific events or exhibitions like AquaNor 2007. Contact with fish farming associations and international organizations

to spread knowledge about Netwash. Socio-economic studies on aspect of the project results and activities that promote or enable synergies with education.

Progress:
The dissemination activities performed in the Netwash project are summarized in the table below.

Planned/actual dates	Type	Type of audience	Countries Addressed	Size of Audience	Partner responsible / involved
November 2006	Press release Submitted to Helgeland Arbeiderblad	General public in Helgeland area	Norway	30 000 subscribers	Coordinator/TI
November 2006	Press release submitted to Helgelands blad	General public in Helgeland area	Norway	10 000 subscribers	Coordinator/TI
November 2006	Press release submitted to www.kyst.no	Fish farming industry	Internet – open site	Unlimited	Coordinator/TI
November 2006	Article regarding NetWash in www.kyst.no	Fish farming industry	Internet – open site	Unlimited	Coordinator/TI
November 2006	Article regarding NetWash in Helgeland Blad	General public in Helgeland area	Norway	10 000 subscribers	Coordinator/TI
May 2007	Presentation of project at the conference hss 07	Researchers Developers Students Law makers Fish farming industry	Scandinavia	450	Coordinator/TI
August 2007	Stand with poster and info brochures at Aqua Nor 2007	Research & development community, producers, end users and law makers	Worldwide	14 324**Fel! Bokmärket är inte definierat.**	TI / All
September 2008	Stand with poster and info brochures at Aquaculture Europe 2008	Producers, end-users in Europe	Europe	>1000	TI/Pera

In November, 2006, a press release was sent out to Helgeland Arbeiderblad (www.helgeland-arbeiderblad.no) Helgeland Blad (www.hblad.no) and www.kyst.no with general information of the project NetWash. A copy of the press release is shown below in Figure 1. The press release in Helgeland Arbeiderblad and Helgeland Blad was aimed at the general population in the area of Helgeland, where the Coordinator is located to bring attention to the project and to show what at small, local company could achieve; participation in an international EU project for product

development. The press release in www.kyst.no was aimed at the Norwegian fish farming industry. www.kyst.no is an open and free news web-page for the fish farming industry in Norway and is reported as one of the leading news-site for the industry with electronic articles from the magazine “Norsk Fiskeoppdrett”.

In addition, the Nerwash project has been represented on the hss 7 conference in Bodø, Norway, The AquaNor Exhibition 2007 in TrondHeim, Norway and the Auaculture Europe Exhibition 2008 in Krakow, Poland.

2.3 Deviation and correction of the activity plan

The table below summarizes the deviations from the work program, and the corrective actions taken.

Work package no.	Title	Deviations from plan	Corrective action
WP1	Enhanced Scientific Understanding	Detailed Input for an electronic control system which is partly submerged is no longer needed	An alternative and believed a better solution for system control was chosen by the consortium during a technical meeting which will be more robust, can be placed on land and will be less expensive. As the newly chosen control system will be mechanical and will be place on land, the need for detailed investigation for a partly submerged electronic control system is no longer needed in the project
WP2	Development of an Innovative Net Cleaning "Mouth"	As the prototype from GUT experienced difficulties, a second prototype was developed at TI. This prototype has been taken through testing and validation.	Reports are written on both prototypes
WP3	Development of Housing	Task less extensive than foreseen as no buoyancy control system is needed.	More work has been done on the Netwash prototype as work has been ongoing by both

			GUT and TI and not only by GUT as originally planned
WP 5	System Integration and Industrial Validation	System Integration and validation of the technology has been performed on the TI prototype only.	Work on both prototypes are detailed in the reporting but testing and validation is only specified for the TI prototype

2.4 Work package deliverables update

Deliv N	Delive rable	Delivery Date	Natu re	Disseminatio n
D1.1	Report with detailed description of the requirements of the foreseen NetWash system, especially on technical requirements of camera, buoyancy control system, and ROV control, based on the loads and forces influencing on submerged vehicle.	M6	R	C O
D2.1	Prototype of suction mouth with integrated brushes and adjustable pump system.	M30	P , R	C O
D3.1	Report on choice of camera & illumination system; and solution for buoyancy control and implementation	M25	R	C O
D3.2	Report on complete housing for the suction mouth and brushes developed in WP2 with integrated control systems for movement and inspection	M30	R	C O
D4.1	Report on control system for brushes rotation speed and suction water flux, stability and buoyancy, and movement by thrusters.	M25	R	C O
D5.1	Integrated prototype.	M27	P	C O
D5.2	An evaluation report on the performance of the complete and integrated NetWash technology.	M30	R	R E
D5.3	Validation of the commercial viability of the technology application, including feature benefits and cost implications by representatives of the target market sectors, i.e. the end-users.	M30	R	P U
D6.1	Report on potentially competitive patents and a plan for patent application(s) if required with exploitation agreements between the partners.	M30	R	R E

D6.2	Two papers presented at 4 conferences and major exhibitions and two publications in the form of editorials, technical papers or trade press.	M30	O	P U
D7.1	Dissemination and Use Plan, DUP (-draft at mid-term and final at the end of project).	M12,30	R	C O
D7.2	Mid-term review report.	M12	R	C O
D7.3	Publishable final report.	M30	R	P

2.5 Work package milestones update

WP No.	Milestone Deliverable	Month Available	Method of Verification	Partner Responsible
1	New scientific knowledge related to fouling issues, materials technology and external influences, and the spread of such knowledge among the partners. Includes the generation of specific requirements that must be considered	Month 6	Report connecting fouling issues to the requirements of the technology to be developed	TI
2	The development of suction mouth that during testing shows the characteristics given in the work package objectives.	Month 25	Report on test results	GUT
3	The development and construction of housing with integrated inspection, buoyancy and movement systems giving the complete device, including the suction mouth developed in WP2 stable and movable	Month 25	Integrated sub-part prototype and WP report	BTT
4	The completed control systems for every controllable part of the device, i.e. brushes rotation speed, water flux through the netting generated by pump intensity, and movement by controlling of thrusters on the housing.	Month 25	Report and management instructions description	PERA
5	The integration into a complete NetWash system and industrial validation that establish: - functioning pilot plant in accordance with system specifications - Industrial validation to the project partners and representatives of selected sector groups up to industrial objectives.	Month 30	Documentation on prototype functionality and industrial validation against objectives	TI

6	Strategy and implementation plan for the translation of the project results into a protectable form through patenting.	Month 30	Verification by discussion and agreement of all partners that the plan and actions will secure the knowledge for commercial use and exploitation	Seloy
6	Transfer of the project knowledge from the RTD performers to the SMEs participants.	Month 30	Completion of technology transfer events, secondments & placements of staff. Partner satisfaction questionnaires.	Seloy
6	Completed promotion of the benefits of the developed technology and knowledge beyond the consortium to potential industrial user communities	Month 30	Report detailing the activities completed and the specific companies engaged & feedback and willingness to adopt the results through the partners	Seloy
7	Coordinated payment and distribution of money.	Month 1,12,30	Payments	Seloy
8	Delivery of task and management reports according to contract.	Month 6,12,30	Reports	Seloy
9	Mid-term management meeting to review progress against objectives and plan future work. Draft DUP presentation.	Month 12	Accomplishment of Mid-term meeting & meeting minutes. Reports	Seloy
10	Final Management meeting to evaluate achievements of project objectives and make plans for bringing the project system to market. Final DUP	Month 30	Final meeting and Final report	Seloy

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With some modification to the original plan, all Milestones have been reached.

SECTION 3 – CONSORTIUM MANAGEMENT

3.1 Consortium management tasks and achievements

Objectives:
Overall project management and coordination. Management of project external relations. To ensure that all knowledge is created, managed and disseminated in a coordinated and coherent manner, along with all technical activities, legal aspects.

Efficient management of time & resource allocation at a consortium level, facilities, representatives at meetings & general administrative duties, coordination of the Work Packages. Creating and negotiating IPR ownership and agreements within and outside the partnership. Prepare Dissemination and Utilization Plan (DUP). Preparation of, updating and managing the consortium agreement between the participants, obtaining audit certificates. Identification and assessment of potential impact within the project and related to the use and application of results.

Tasks and Achievements:
The final DUP has been completed including information on the dissemination activities. The project was presented at a stand at the AquaNor 2007 Exhibition, held in Trondheim, Norway as well as Aquaculture 2008 in Krakow, Poland. Poster and informational brochures of the project were made available at the stand for the visitors. The partners have established a web-site with information of the project and its progress (www.netwash-project.com). A press release to Helgeland Arbeiderblad, Helgelands blad and www.kyst.no were made. Articles with information about the project have been published in www.kyst.no and in Helgeland Blad (http://www.hblad.no/nyheter/article61047.ece)

Both technical and management meetings have been held according to plan and need.

3.2 Contractors

The table below summarizes, in general terms, the contributions performed by each contractor

PROJECT PARTICIPATION			
Participant No.	**Participant short name**	**Country**	**Participant contribution second period**
1	Seloy Undervannsservice AS	Norway	Seloy Undervannsservice AS has been acting as the coordinator of the project and has taken great part in the technical management of the project and have provided important end user requirement and design input needed for the development of the Netwash system.
2	Niebling Technische Bürsten GmbH	Germany	Niebling has provided input for the development and design of the prototypes of the brushes to be used in Netwash system and also had discussions with TI on the design as a whole.
3	BTT Automatyka Sp. zo.o.	Poland	BTT withdrew from the project due to the substantial loss of personnel within their company causing them not to be able to contribute as they had anticipated to the project
4	Tsurumi-Intec Pump AB	Sweden	Tsurumi has contributed with input to pump specification for the Netwash system
5	Imenco Engineering AS	Norway	Imenco has provided technical input for the camera and illumination to be used in the Netwash system and have also provided TI with camera and light for the Netwash prototype tested in Brønnøysund, Norway.
6	Productos Mesa S.A.	Spain	Productos has given input to specifications for the hose to be used in the Netwash system
7	RefaMed s.r.l.	Italy	
8	Marina 2000 s.n.c	Italy	
9	Hradfrystihusid-Gunnvor hf.	Iceland	Has provided valuable end user input and cost calculations
10	National Institute of Technology (Teknologisk Institutt as)	Norway	TI has played a major part of the work which is completed in WP 1 and in WP3 and WP5 having built and tested the prototype. In addition, TI has contributed in project coordination activities, assisting the coordinator of the project, Seloy Undervannsservice AS
11	PERA Innovation	UK	Pera has taken part in WP 1 with respects to technical meetings and evaluations of a new selection of control system in WP 4.
12	Gdansk University of Technology	Poland	GUT has worked on a prototype net washer that unfortunately never got to the point of testing in the sea.

3.3 Project timetable and status

#	TASK	PARTNERS		MONTHS																							
		Resp	DE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24-30
1.0	**Scientific Understanding of Requirements**	**TI**	**6**																								
1.1	Specific requirements related to fouling issues	TI	5																								
1.2	Materials & Control Systems	Pera	3																								
1.3	External factors on submerged device	GUT	6																								
2.0	**Net Cleaning Mouth**	**GUT**	**10**																								
2.1	Design and development	GUT	8																								
2.2	Water-driven power system for brushes	TI	9																								
2.3	Development & fitting of brushes	TI	9																								
2.4	Integration of pump system and testing	TI	10																								
3.0	**Development of Housing**	**BTT**	**14**																								
3.1	Development and design of housing shell	Seloy	12																								
3.2	Choice & testing of camera and illumination	Imenco	14																								
3.3	Construction of buoyancy hardware	BTT	13																								
3.4	Integration of thrusters for movement	GUT	14																								
4.0	**Control System**	**Pera**	**16**																								
4.1	Water flux & brush rotation speed	Pera	12																								
4.2	Buoyancy and Stability	GUT	16																								
4.3	Control system for thrusters	Pera	16																								
5.0	**Integration & Industrial Validation**	**TI**	**30**																								
5.1	Assembly of NetWash system	TI	30																								
5.2	Validation	TI	30																								
6.0	**Innovation Related Activities**	**Seloy**	**30**																								
6.1	Protection of IPR	Seloy	30																								
6.2	Absorption of results by proposers	Seloy	30																								
6.3	Dissemination of knowledge	Seloy	30																								
6.4	Socio-economic aspects	TI	30																								
6.5	Promotion of exploitation	Seloy	30																								

The changes in the project timeline are indicated..

3.4 Co-ordination activities in the period

No	Date	Purpose of meeting	Location
1	26/10/2006	Kick-Off Meeting	Oslo, Norway
2	23/11/2006	Technical Meeting GUT-TI	Oslo, Norway
3	23/01/2007	Technical Meeting TI-Niebling	Burgbernheim, Germany
4	31/01/2007	Technical Meeting TI-Imenco	Haugesund,Norway
5	15/02/2007	3month Technical	Gdansk, Poland
6	15/02/2007	Meeting BTT-TI	Gdansk, Poland
7	21/03/2007	Technical Meeting Tsurumi-TI	Oslo, Norway
8	11/04/2007	Technical (Phone) Meeting, Seloy-TI	Oslo/Seloy
9	22/05/2007	6month Management and Technical Meeting	Sardinia, Italy
10	13-17/08/2007	AquaNor Fair	Trondheim, Norway
11	05/02/2008	12 month Management and Technical Meeting	TI, Oslo, Norway
12	26/06/2008	Technical Meeting TI-GUT	Gdansk, Poland
13	25/07/2008	Technical Meeting TI-Niebling	Burgbernheim, Germany
14	12-14/09/2008	Aquaculture Europe 2008	Krakow, Poland
15	14/10/2008	20-month Management and technical Meeting	TI, Oslo, Norway
16	19/12/2008	Technical telephone meeting	
17	23/06/2009	Final Meeting	Sandnessjøen, Norway

In addition to the activities mentioned in the table above, it is worth mentioning that the 6 month meeting was joint effort with the EC supported EscapeProofNet project, giving the partners a possibility to expand their network within the aquaculture.

SECTION 4 – OTHER ISSUES

Marina2000, have not contributed as expected during the project. The work originally planned for this partner has been taken over by other partners. Testing and validation has been performed by TI at Norsk Havbrukssenter, Brønnøysund Norway.