PROJECT NO: COOP-CT-2005-017977

IntelFishTank

Development of an "intelligent fish tank" for cost effective aquaculture production through control of water quality in each different fish tank in an aquaculture plant

Co-operative Research (CRAFT)

Horizontal Research Activities Involving SMEs

Publishable Activity Report – Reporting Period 2
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Project Coordinator: Plastsveis AS Version: Final

CONTENTS

PROJECT INFORMATION

PROJECT NO:	FP6-017977
CONTRACT NO:	COOP-CT-2005-017977
TITLE OF PROJECT:	Development of an “intelligent fish tank” for cost effective aquaculture production through control of water quality in each different fish tank in an aquaculture plant
COORDINATOR:	PLAST-sveis AS
SME EXPLOITATION MANAGER:	PLAST-sveis AS

PROJECT PARTICIPANTS				
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11	OxyMat AS	OxyMat	Denmark	SME proposer
4	Aswega Limited	Aswega	Estonia	SME proposer
13	Artec Aqua AS	Artec	Norway	SME proposer
15	Lighthouse Caledonia Ltd	Lighthouse	United Kingdom	LE Enterprise
14	Marine Harvest Norway AS	Marine Harvest	Norway	LE Enterprise
6	The National Institute of Technology, Norway	TI	Norway	RTD performer
7	Production Engineering Research Association	Pera	UK	RTD performer
8	The Gdansk University of Technology	GUT	Poland	RTD Performer

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SECTION 1 – PROJECT OBJECTIVES AND MAJOR ACHIEVEMENTS DURING THE REPORTING PERIOD

1.1 Overview of General Project Objectives

Overall Projective Objective

Our idea is to develop a cost effective, high efficient system for oxygenation and water distribution in an integrated aquaculture tank system for land based fish farming enabling **control of water quality at in each different tank** in an aquaculture plant. The principle innovation in this project is the development of a sensor- and control system for oxygenation of water and for control of water speed in order to optimize water quality and growth environment for production of different types of fresh- and saltwater fish in land based fish farming industry in Europe. Control of oxygenation of water in aquaculture tanks is essential for development of fish farming plant with recirculation of water and recirculation of water have strong environmental advantages as well as improve growth environment for biomass by increasing density of fish in aquaculture tanks as well as increase the growth rate, hence improve productivity, reduce costs and improve cost/efficiency and competitiveness of land based fish farming in Europe. Each fish species and each size of a species has different optimal swimming speeds which are influenced amongst other by temperature. The water streamer to be developed in our project will make it possible to adjust the water speed to an optimal pre-set value determined by the farm personnel, based on the species, its size and the conditions of which it is held at.

The main innovations and development routes in the project include:

- **Development of a patentable, low pressure oxygen distributor** That is able to balance other gases in the water including nitrogen and carbon dioxide, delivering the optimum amount of oxygen to the specific requirements of fish species at specific phases in their life cycle and in specific densities in the tank.
- **Development of a patentable sensor system** able to provide control feedback to the low pressure oxygen distributor, based on real-time measurements of oxygen, carbon dioxide and nitrogen.
- **Development of an intelligent, water stream generator** that can accurately control water currents within the tank, irrespective of its size and integrated into the water inlet and outlet geometries within the tank and the cleaning effects of currents on the tank walls.

The Scientific Objectives of our project are:

- enhanced understanding of specific biological requirements of specific species (salmon, trout, sea bass and sea bream) and the factors within their habitat (particularly water quality) that impact onto their health, growth and survival at different stages in their life-cycle.

- enhanced understanding of the creation and control of micro-bubbles in to specific dimensions to balance mass with spherical surface area and surface tension in the water to avoid breakage or agglomeration O_2 into the water during transit in currents across a tank and enable the bubbles to act as a vehicle to attract and transport nitrogen compounds out of the tank.
- enhanced understanding of water flow and current in aquaculture tanks in order to generate water flow throughout the complete volume of the tank in order to effectively transport micro-bubbles in the tank as well as ensure self cleaning efficiency and effective transport of particulate matter from food spills and feces to the tank outlet independent of the volume of the tank and density of biomass

The Technological Objectives of our project are:

to develop a cost effective, high efficient system for oxygenation and water distribution in an integrated aquaculture tank system for land based fish farming enabling **control of water quality at in each different tank** in an aquaculture plant. The principle innovation in this project is the development of a sensor and control system for oxygenation of water that:

- can be used both for fresh and salt water
- can be used both for bottom fish and free swimming species
- ensures an efficiency of at least 95 % with respect to oxygenation of water.
- create a homogenous water quality in the tank with a variation of oxygen saturation of less than 10 % regardless of height and diameter of the tank making it possible to increase the normal density of the biomass in the tank with at least 10 % percent
- has a adjustable water current within a range of 8 to 25 cm/sec with a variation of less than 20 % in 95 % of the volume in the tank for self-cleaning effects and transportation of organic matter to water outlet
- controls and adjust the oxygen saturation within the range of 50 to 120 % based on requirements for different species and different phases of the life-cycle.
- include a real time measurement of organic matter integrated in water outlet for evaluation of cleaning effects and can be included as evaluation of feeding control
- Have an energy consumption of less than 4,1 W per unit inflow of water in cubic meter pr hour for water with a salinity of 33 ppt and a energy consumption of less than 15,0 W per unit inflow in cubic meter pr hour of fresh water.
- Can be manufactured to a price of less than 75 Euro per m3 water in tank for a tank with a diameter of 8 meter and a height of 2.5 meter.

Relation to Current State-of-the-Art

Today, there are several technologies for oxygenation of water in aquaculture tanks. Unfortunately, all these methods have several limitations:

- Oxygen dissolving through positive pressure of part of water amount in tank. Only 10 – 20 % is oxygenated and circulated into main tank after oxygenation. This method is energy consuming, requires pumps, low control and adjustment possibilities, low efficiency of oxygenation.

- Oxyprocess – use of liquid oxygen. Only one supplier of equipment, high efficiency of oxygenation, high cost,
- Perforated hoses and ceramic stones. Low efficiency in oxygenation. Disturbance in tank hydraulics, high costs
- Lack of control due to lack of on-line sensor and monitoring systems including monitoring of oxygen, CO2, TOC and nitrogen compounds.

The main technical barriers for the development of improved and more cost effective and highly efficient systems for oxygenation relate to the following issues:

- There is no reliable method available for the generation of micro-bubbles in sufficiently accurate/controlled dimensions to avoid them breaking or agglomerating with the water which reduces their capability to function as an effective transporter of oxygen into the tank and CO2 and nitrogen compound out of the tank.
- There is no sufficiently accurate or effective independent oxygenation process that can be applied to produce tailored environments for each individual tank within a fish farm, to cater for the specific requirements of different species during different phases of the life cycle.
- There is no reliable method available to accurately control the water flow throughout the complete volume of the tank in order to effectively transport micro-bubbles in the tank as well as ensure self cleaning efficiency and effective transport of particulate matter to the tank outlet independent of the volume of the tank and density of biomass.

Our innovations and development routes to overcome these technical barriers include obtaining:

- **enhanced understanding of specific biological requirements of specific species** (salmon, trout, sea bass and sea bream) and the factors within their habitat (particularly water quality) that impact onto their health, growth and survival at different stages in their life-cycle.
- **enhanced understanding of the creation and control of micro-bubbles** in to specific dimensions to balance mass with spherical surface area and surface tension in the water to avoid breakage or agglomeration O_2 into the water during transit in currents across a tank and enable the bubbles to act as a vehicle to attract and transport nitrogen compounds out of the tank.
- **enhanced understanding of water flow and current in aquaculture tanks** in order to generate water flow throughout the complete volume of the tank in order to effectively transport micro-bubbles in the tank as well as ensure self cleaning efficiency and effective transport of particulate matter from food spills and feces to the tank outlet independent of the volume of the tank and density of biomass

1.2 Project Objectives and Achievements for Reporting Period 2

The specific objectives and achievements post Period 1, from January 1st, 2007, through June 30th, 2008, are summarized in the table below.

Deliverable No	Task No.	Objective	Achievements During Reporting Period	Partners Involved
D.2.2	2.4	Prototype of multisensor	**Completed** Evaluation of the available sensors and a selection of appropriate sensors for the IntelFishTank system are completed. A control system has been selected and programmed to receive input values from the sensors and provide output signals to control the oxygen diffuser and the water streamer, based on set-point values.	All SME and RTD partners
D.2.3	2.3	Integrated oxygen gas diffuser and multi sensor – development of algorithms.	Removed as a deliverable by Amendment to contract. Work on this task will be included as part of task 4.1	
D.2.4	2.4	Functional test report	**Completed** Following the work completed in Period 1 of Task 2.1, a functional test of the initial small scale prototype of the oxygen diffuser was performed both in fresh and saline water. Several adjustments to the initial prototype were done to improve the efficiency and further functional tests were performed. Details of the functional test can be found in D2.4	Plastsveis Artec Pera TI

D.2.5	2.5	Risk assessment report	**Completed** A risk assessment report has been produced which details the initial steps taken in analyzing the potential failures that could occur in the system in the low pressure oxygen generator and associated monitoring and control system. The failures that rated high RPN numbers have been examined and methods or procedures to reduce or mitigate the risks have been implemented. This process is the first step in the life of the FMEA and needs to be re-visited each time changes are made to the system or when situations arise. The full Risk Assessment Report can be found in D2.5	All
D.3.3	3.3	Integrated prototype in PE tank	**Completed** This task was not scheduled to be finished until Month 13, but was however completed before schedule, during Period 1. A final report (D3.3) was included as part of Period 1 report and is therefore not included in this Period 2 report.	Plastsveis Tsurumi Aswega GUT
D.3.4	3.4	Functional test report	**Completed** Functional testing of a small scale water streamer is completed as well as a functional test of a full scale water streamer with nozzles. For details of the results, please see D3.4	Plastsveis Tsurumi Aswega Artec GUT TI Pera
D.3.5	3.5	Risk assessment report	**Completed** A risk assessment report has been produced for the water streamer development. The full Risk Assessment Report can be found in D3.5	GUT

D.4.1	4.1	System Integration	**Completed** Based on the work performed in WP 2 and WP 3, full scale prototypes of the oxygen diffuser and water streamer were built and integrated with the multi sensor and control system at the site of Ytre Standal, one of Marine Harvest's fish farm sites. Programming of the control system was completed. Information on the system integration can be read in full in D4.1	All
D.4.2	4.2	Validation Test	**Completed in part** A full scale validation test of the water streamer has been completed. Validation testing on the oxygen diffuser in fresh water has been completed. Testing of oxygen diffuser in salt water was not completed within the project period as the fish in the tank were not ready for the smolt phase at the time of testing and because the fish farm of installation changed their procedures, not longer using salt water in their land based tanks. Artec and Marine Harvest are in talks of planning a test of the oxygen diffuser in salt water post project in tank 38 at Ytre Standal. Marine Harvest is evaluating the possibility of allowing the use of salt water for the test purpose only. With all the project equipment already in place, this test should be possible to complete over a period of 1-2 days. Details of the findings of the validation test can be found in D4.2	All
D.5.1	5.1	A report on potentially competitive patents and a plan for patent application(s) if required with exploitation agreements between the partners.	**Completed** Patent has been achieved on the oxygen diffuser and a patent application, both in Norway and a PCT application, is on file for the water streamer	Plastsveis Artec TI

D.5.2	5.2	Production of support material for transfer of the knowledge to the partners through case studies and a generic design guide.	**Completed** Support material for the partners have been completed and full details can be found in D5.2	Plastsveis Artec Tsurumi Oxymat Aswega Lighthouse Marine Harvest TI
D.5.3	5.3	2 papers presented at conferences and major exhibitions and production of 2 publications in the form of editorials, technical papers and trade press.	**Completed** The project has been presented at four (4) exhibitions / conferences and has been featured in two (2) magazines. Details can be found in full in D5.3	TI GUT Pera
D.5.4	5.4	A report on the standards, ethical and regulatory aspects of the exploitation of the results	**Completed** A report on the standards, ethical and regulatory aspects of the exploitation of the results have been written. Details can be found in full in D.5.4	Plastsveis TI
D.5.5	5.5	Relevant companies contacted directly to promote the project results and stimulated to apply or use the results in their future product strategy.	**Completed** By having end-users participate in the project, the IntelFishTank technology has effectively been promoted to two of the larger end users in the industry, namely Marine Harvest and Lighthouse Calidonia Ltd. In addition, companies have been contacted directly through presentation of the technology at aquaculture exhibitions, through daily communication with customers and through press articles and project web-page. Even before the project end date had been reached, an order for a manual Variostreamer has been obtained from one of Artec Aqua AS's customers, Neptun Settefisk AS.	All

D.6.1	6.1	Delivery of an initial and complete Plan for Using and Disseminating Knowledge. Delivery of patent applications if applicable	**Completed** A final Plan for Using and Disseminating Knowledge has been written and can be read in full in D6.1	All

SECTION 2 – WORK PACKAGE PROGRESS OF THE PERIOD

2.1 Work package objectives

The specific work package objectives for the eighteen month period of reporting period 2, i.e. 01st of January 2007 to 30th of June 2008 of the project are summarised in the table below.

Work-package No	Workpackage title	Lead contractor Short Name	Person-months	Start month	End month	Deliverable No
1	Scientific Understanding of aquatic environment in aquaculture tanks	TI	18,0	1	7	D1.1,D1.2,D1.3
2	Development of low pressure generator	Pera	18,5	3	13	D2.1,D2.2, D2.4, D2.5
3	Development of water stream generator	GUT	18,5	5	13	D3.1,D3.2,D3.3, D3.4, D3.5
4	System Integration and Industrial Validation	TI	29,0	13	30	D4.1,D4.2,
5	Innovation Related Activities	Plastsveis	17,2	1	30	D5.1,D5.2,D5.3, D5.4, D5.5
6	Consortium Management	Plastsveis	3,35	1	30	D6.1
7	Project Management	TI	10,0	1	30	
	TOTAL		114,55			

2.2 Overview of work package technical progress

The following summarizes the work carried out in the second reporting period, i.e. the 18 month period from 01.01.2007 to 30th of June 2008. The objectives of each work package are presented, followed by a presentation of technical progress and achievements in the different tasks. Further details are given in the detailed reports on the tasks, which can be found in the appendices covering the deliverables finalised within reporting period 2.

WP 2: Development of low pressure oxygen generator

Objective

Develop of a low-pressure oxygen generator, including use of materials and design of oxygen outlet into water and control by hydrometer. Test design of oxygen outlet to ensure that they will meet the requirements characterized in WP 1. Optimize generator design for efficient and optimum oxygenation. Design generator and build prototype.

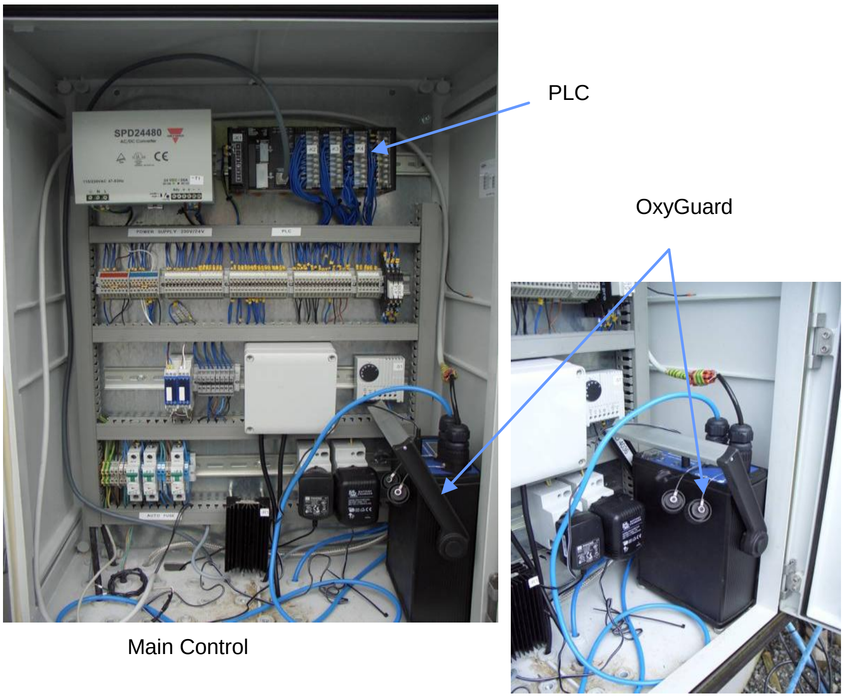
Progress towards objectives

Task 2.2 – A prototype of the multi sensor for TOC, CO2, oxygen and total nitrogen

Task leader: 8 **Partners involved: 8, 11, 1, 4, 7, 9**

Progress: Complete

Results: Work on development of the prototype of the multi sensor and control system is complete. Appropriate sensors for CO2, O2, pH, Temperature, Conductivity, Water Velocity and Water Flow is complete and the PLC system program has been written for control of the oxygen diffusers and water streamer based on set-point values and input values from sensors.



Main Control

Discussion: A multi sensor and control system based on a programmable logic controller (plc) has been designed and built to accept the inputs from the various sensors and to operate actuators that control Oxygen flow and water flow to achieve the required oxygenation of the water. Control algorithms have been written that take the sensor data compare this with required the water conditions and determine the necessary actions required to meet the set conditions.

Supervisory control of the plc is implemented by a pc based graphical user interface that communicates with the plc over internet protocols. This system allows a number of remote pc's to access the control system and provides monitoring and access screens to view the recorded data from each sensor and to adjust the operating levels within the tank. The system also allows access to the plc program to facilitate modifications should the need arise.

Further details can be found in Deliverable 2.2 (Amended version)

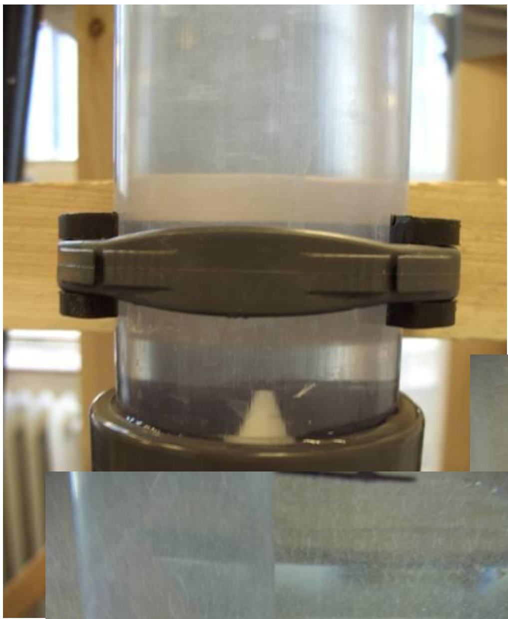
Task 2.4 – Functional test report

Task leader: 7   Partners involved: 1, 7, 8

Progress: Completed

Results: Functional testing of the prototype of the oxygen gas diffuser complete

Very Tiny bubbles above diffuser, only just visible by eye



Micro bubbles exiting feed pipe and bottom of clear tank

Discussion: Several functional tests have been run to determine optimal choice of material as well as how to achieve optimal formation and distribution of micro bubbles in both fresh and saline water. The results from the tests show that micro bubbles can be created both in fresh and salt water with the prototype produced. In salt water it was found that micro bubbles can be created in quantity at relatively high gas flow rates, while in fresh water, micro bubbles can only be formed at low gas flow rates, as increasing the flow causes the bubbles to coalesce, forming larger bubbles. EPDM and SBR were the two materials which proved to be the best choice for the oxygen diffuser based on the trails performed. Each of these materials is easily obtainable in the industry. It remains to be seen from the full scale tests if the low flow rate required for micro bubble formation in fresh water will be successful for sufficient oxygenation of the water in the fish tank at the site of Ytre Standal. The efficiency in salt water is expected to greatly surpass that of fresh water. It should be noted that it is also of importance to check each oxygen diffuser after production to ensure even distribution of bubbles. Uneven distribution of bubbles can be altered by adjusting the force used when assembling a unit.

Further details can be found in deliverable 2.4.

Task 2.5 – Risk Assessment Report and Contingency Planning

Task leader: 8 **Partners involved: All**

Progress: Complete

Results: A FMEA has been made and can be found in D2.5

Discussion: D2.5 details the initial steps taken in analysing the potential failures that could occur in the system in the low pressure oxygen generator and associated monitoring and control system. The failures that rated high RPN numbers have examined and methods or procedures to reduce or mitigate the risks have been implemented. This process is the first step in the life of the FMEA and needs to be re visited each time changes are made to the system or when situations arise. At this stage of the project we are still in the development stages when the system has been run for a period of time changes to hardware and software will be noted for and the FMEA updated to suit.

This FMEA will also be used to enable an FMEA for the entire system to be built up to help produce a full production system.

WP 3: Development of water stream generator

Objective

Develop and build a prototype water stream generator to ensure a homogenous and effective distribution of oxygen in water in aquaculture tanks taking into consideration tank design as well as design of water inlet and outlet.

Progress towards objectives

Task 3.2 – Integrate prototype with water flow meters – development of algorithms.

Task leader: 11 **Partners involved: 1, 4, 7, 8, 9, 11**

Progress: Complete

Results: A small scale prototype of the water streamer were integrated with water flow meters in a small scale tank and installed at GUT where functional testing were run.

Discussion:

A prototype of the Water Stream Generator has been integrated with a flow meter of type WS-40 as well as an Acoustic Doppler Velocity (ADV) sensor. The integration of these components will make it possible to during the functional test find a relationship between hole size, flow through streamer and water speed in tank. It was determined to include the findings of this relationship in the functional test report, Deliverable 3.4.

Further details can be found in deliverable 3.2.

Task 3.3 – Integrated prototype in PE tank

Task leader: 1 **Partners involved: 1, 7, 9, 10**

Progress: Complete
Results: The prototype of the water streamer has been successfully integrated in a PE tank and functional testing is currently in progress.

Discussion: For functional testing, it was deemed appropriate to use a model of a real size fish tank, scaled down 1:4. The model was based on dimensions of a typical fish tank in use on the market today. The prototype of the water stream generator was built to fit the scale of the model tank. In addition to integration of the water streamer in the PE tank, velocity Doppler sensor and water flow meter were integrated to be used during the functional testing to establish which effect the water streamer had on the velocity in the fish tank at given flows and hole openings.

D3.3 was delivered as part of the reporting of Period 1 and is hence not included as in the Period 2 report

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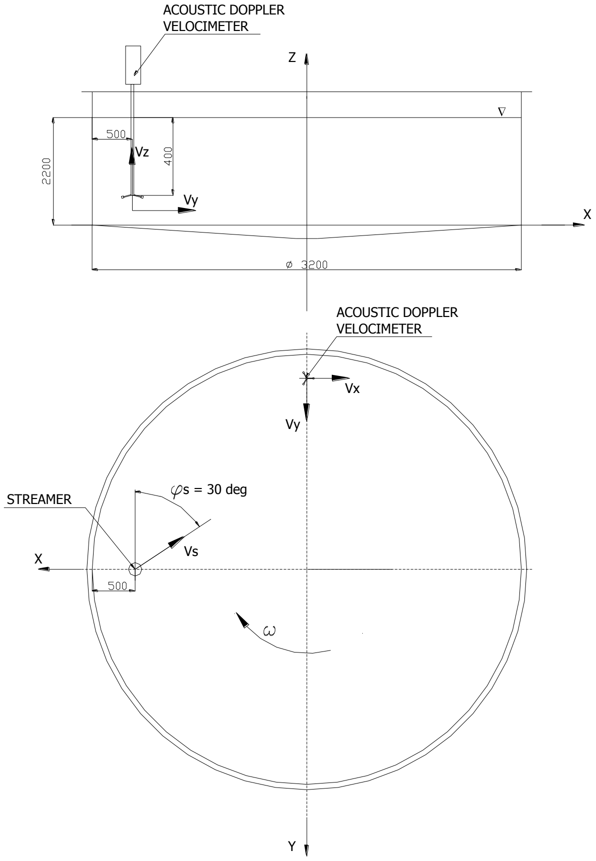
Task 3.4 – Functional test report

Task leader: 9 Partners involved: 1, 4, 7, 8, 9, 10

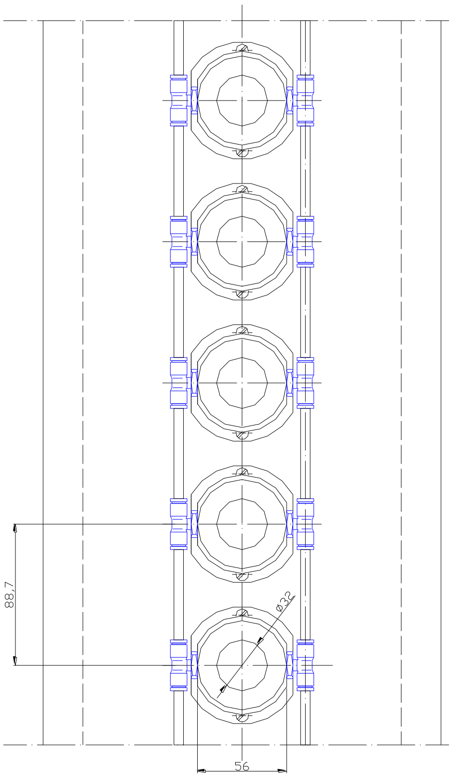
Progress: Complete

Results: Functional test was completed both of a small scale prototype with holes and of a comparison test of full scale prototypes with drilled holes and with nozzles.

Discussion: Testing at the facility of GUT was completed. The enclosed D3.4.1 report summarizes results of measurements of water velocity field in 1:4 scale model of fish farming tank described in Deliverable Report D2.4.2 as well as discuss further measurements done to find relationship between streamer hole size, water flow and water velocity. Analysis of the initial measurement results indicates that optimum location of the streamer is Rs = 20% of tank radius measured from the tank wall while higher water velocities were achieved for the streamer water jets panned φs = 55° from surface perpendicular to local radius. For this streamer location and orientation further supplementary measurements were done in four (4) tank cross sections and influence of water flow rate (Q) and dimensions of streamer holes (Dstr) were investigated. Four water flow rates and five hole sizes were tested. Average water velocity in real tank was also calculated based on test results.



Following the small scale test, it was decided to explore the development of a water streamer with nozzles and compare this with a water streamer with holes to find potential difference in efficiency.



Full scale prototypes of water streamers, one with holes and one with nozzles, were built and tests were run. The results of experiments with articulated nozzles and comparison with drilled holes are as follows:

1. Application of the nozzles increases the water propelling capability of the streamer due to better shapes of inlet and outlet and therefore reduction of the local turbulences.

   As can be seen of graphs in D3.4; to achieve circulation water velocity of V = 0,01 m/s
   - the flow of Q = 830 l/min is required in case of the traditional streamer with drilled holes;
   - the flow of Q = 450 l/min is required in case of articulated nozzle streamer.

2. It is possible to control circulating water velocity in tank by means of articulation of nozzle openings.

3. Reduction of nozzle openings for the same flow increases circulating water velocity in tank that proves principal assumption of the project in this area.

Practical remarks:

1. For (future) commercial system a Bellofram membrane pump is proposed. This solution will provide seal free design that will assure leak, corrosion and maintenance free operation.

2. To make possible automatic control of water flow the pump needs to be equipped with an electric servo actuator.

3. To reduce cost of commercial system single row of unions can be applied on streamer.

For further details see Appendix D3.4.1 & D3.4.2.

Task 3.5 – Risk Assessment Report and Contingency Planning

Task leader: 9 **Partners involved: 9**

Progress: Complete

Results: A risk assessment report for the development of the water streamer has been completed.

Discussion: The report can be read in full in D3.5

WP 4: System Integration and Industrial Validation

Objective
To test and make the integrated control system for oxygenation of water in aquaculture tanks meet the project objectives. To validate that the technology created is capable of reaching a manufacturing performance to meet the specifications and cost models of the industrial target sectors.

Progress towards objectives:

Task 4.1 – System Integration

Task leader: 7 **Partners involved: All**

Progress: Complete

Results: A full scale prototype of the components of the IntelFishTank system has been integrated

Discussion: A full scale prototype of the water streamer, two full scale prototypes of the oxygen diffuser and a multi-sensor and control system have been integrated at the land based fish farm belonging to one of the partners in the project, Marine Harvest Norway AS, at Ytre Standal. The project was allowed to install the system in tank 38 at the farm for the purpose of running validation testing both in fresh- and salt water, validating the system for use for both fresh and salt water species.

Task 4.2 – System Validation

Task leader: 7 **Partners involved: All**

Progress: Validation testing of the water streamer is complete. Validation testing of the oxygen diffuser in fresh water is complete. Validation testing of the oxygen diffuser in salt water remains and is being planned for post project.

Results: System validation of the IntelFishTank system has taken place at Ytre Standal in Norway, at a land based fish farm owned by Marine Harvest Norway, for the water streamer and for the oxygen diffuser in fresh water.

Discussion: The IntelFishTank technology has been tested for free-swimming fish in freshwater in a commercial fish farm. The CO_2 concentration in the fish tank has been proven well controlled by the sensor and PLC system controlling the flow rate into the tank. Provided the flow rate and water pressure is adequate, the CO_2

concentration stays very close to target level, decided by the user. This will lead to better water quality, better fish growth and less time spent by the farmer manually changing water flow to the different tanks.

The vario streamer was proven to supply a very homogeneous oxygen distribution throughout the tank as shown in the position series and the drop in oxygen between inlet and outlet was half that normally recorded at smolt farms in Norway. This improved water quality throughout the tank leads to better fish health and growth and potentially higher stocking densities.

The VarioStreamer has provided velocities between 5.6 – 14.1 cm/s. The average velocity, 12.6 cm/s has been proven adequate for self-cleaning of fish pellets and waste products from the tank, as proven by the 24-hour chemical sampling. With the present VarioStreamer and maximum flow rate of 800 l/min, the highest average velocity recorded was 14.1 cm/s. To increase the velocity with the present VarioStreamer with slider design, a greater water flow rate in larger tanks is required. Alternatively the VarioStreamer designed by GUT with rubber nozzle design should be tested in fish tanks during the winter season. This rubber nozzle design has proven to provide higher velocities than the slider design VarioStreamer. However the hydraulics which control the opening and shutting of the pores are suspected to be less robust during freezing conditions in the winter.

The micro bubble oxygen diffuser failed to produce sufficient micro bubbles to saturate the water with oxygen in freshwater during its initial testing. Its efficiency was estimated at 50%. It was therefore not used in the subsequent testing. However the future testing of the diffuser in saltwater is expected to show greater efficiency.

WP 5: Innovation Related Activities

Objective

To ensure that all project results are formulated and compiled into a protectable form and all necessary patents are made. To transfer specific knowledge from the RTD performers to the SME participants to enable them to rapidly apply and embed the technology onto specific products. To broadcast the benefits of the developed technology and knowledge beyond the consortium to potential industrial user communities. To assess the socio-economic impact of the generated knowledge and technology. To formulate the project results into a protectable form and apply for patent protection. To transfer knowledge from the RTD performers to the SME participants through technology transfer events and interactions including x secondments and placements of staff providing for technology transfer. To broadcast the benefits of the developed technology and knowledge beyond the consortium to potential industrial user communities.

Progress towards objectives

Task 5.1 – A report on potentially competitive patents and a plan for patent application(s) if required with exploitation agreements between the partners.

Task leader: 1 **Partners involved: 1, 7, 13**

Progress: Complete

Results: Patent has been granted for the oxygen diffuser. A patent application and a PCT application and patent application in Chile are on file for the water streamer. The oxygen diffuser will be marketed under the trade name "SaturOx™" which has officially been trade marked and the water streamer will be marketed under the trade name "VarioStreamer™" which has been registered.

Discussion:
The IntelFishTank project has resulted in the development of an oxygen gas diffuser, a water streamer and a PLS-system with program for control of the system. A patent has been approved in Norway, patent number 319631, for the oxygen gas diffuser. In addition, a patent application (No. 20072945) was filed on June 11th, 2007 for the water streamer. No objections have come forth on this patent application to date and a PCT-application (No. PCT/NO08/00207 was filed for the water streamer on June 10th, 2008. In addition, a patent application has been filed for Chile for the water streamer. The oxygen diffuser will be marketed under the trade name "SaturOx™" which has officially been trade marked and the water streamer will be marketed under the trade name "VarioStreamer™" which has been registered. Oxymat and Artec Aqua are evaluating the possibility of seeking a patent for the control-program.

Task 5.2 – Production of support material for transfer of the knowledge to the partners through case studies and a generic design guide.

Task leader: 1 **Partners involved: 1,4,10,11,15,14,7, 13**

Progress: Complete

Results: A generic design guide has been completed

Discussion: Full details can be found in D5.2

Task 5.3 – 2 papers presented at conferences and major exhibitions and production of 2 publications in the form of editorials, technical papers and trade press.

Task leader: 7 **Partners involved: 7, 8, 9**

Progress: Complete

Results: **Results:** The project has been presented at four exhibitions / conferences:

- Norway Fish and Aqua International 2006
- Aqua 2006
- IWA World Water Congress 2006
- Aqua Nor 2007
- Skretting Convention participation planned for September 2008

The project has been featured in the following trade journals:

- Hatchery International
- Norsk Sjomat.

Discussion: See D5.3 for full details.

Task 5.4 – A report on the standards, ethical and regulatory aspects of the exploitation of the results

Task leader: 1 **Partners involved: 1, 7**

Progress: Complete

Results: Standards, ethical and regulatory aspects of the exploitation of the results have been evaluated and is presented in the report D5.4.

Discussion: The IntelFishTank technology developed through this project will contribute to improving land-based fish farming. The water quality in each individual fish tank can be user-defined for oxygen and carbon dioxide levels and water velocity leading to an improved and constantly maintained water quality for the fish. This will lead to higher productivity per unit water, better fish welfare and an easier working day for the fish farm employee. These improvements will encourage more sea based fish farms over to land-based farms.

Sea based farms have many environmental disadvantages such as biomass loss due to algae and jellyfish attack or storms and ice-flows. Farmed fish can escape, especially during bad storms and cause genetic pollution to wild populations. Fish disease between farmed and wild fish is more easily spread in sea based operations. Sea based farms occupy attractive coastal situations limiting these sites use for recreation and boating and waste can pollute nearby bathing areas.
As sea-based fish farms move to land-based operations, the following EU directives will be fulfilled, the Integrated Coastal Zone Management, many directives concerning environmental improvements to the Common Fisheries Policy and the Water Framework Directive. In addition our technology directly fulfils several of the goals of the strategy for sustainable European aquaculture, many issues raised in the Federation of European Aquaculture Producers code of conduct and welfare issues for fish.

More indirectly, improved productivity at land-based fish farms will lead to more high quality seafood available to European consumers and more jobs available to those producing, transporting, processing and selling fish. This should encourage consumers to eat more fish and less meat, leading to 600 fewer cases of food poisoning a year. Manufacturing, selling and servicing the IntelFishTanks will bring employment opportunities and improvement of skills in these sectors.
The IntelFishTank project has not in the past, and does not at present; violate any standards, ethical or regulatory aspects of the exploitation of the project results.

2.3 Deviation and correction of the activity plan

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

Work package no.	Title	Deviations from plan	Corrective action
WP2	Development of low pressure oxygen generator	Development of the algorithms of control of the oxygen diffuser in task 2.3 was not completed as part of WP2	It was clear that the algorithms more naturally should take place in connection with the work in WP4.1- in the system integration. Development of the algorithms for control of the oxygen diffuser was completed in connection with 4.1 and is also mentioned in D2.2. By amendment request, task D2.3 was removed from the deliverable list
WP3	Development of water stream generator	Further development of the water streamer and additional functional testing were done beyond the planned work of a second prototype with nozzles	After reviewing the results from the functional testing of the small scale water streamer at GUT, which showed it is possible to control the water speed in a tank by altering the hole openings, however with some limitations in the upper and lower velocity ranges, GUT suggested to explore the potential of improving the efficiency of the water streamer further. GUT developed a water streamer with nozzles which was produced in full scale and tested in comparison with a full scale water streamer with holes. The results showed better efficiency with use of nozzles. The work on the prototype with nozzles was run in parallel to other work in the project in Period 2 and did not interfere or cause any delay in the other tasks or WPs.
WP4	System Integration and Industrial validation	All the components of the IntelFishTank system was in place one month behind schedule in May 2007. However, stable internet access was hard to come by and delay in the start-up of the validation testing was evident. In addition, lack of access to salt water was a possibility due to a virus outbreak at a nearby farm, possibly jeopardizing the window of opportunity to test the system in salt water as planned.	The consortium requested an extension of the project period to ensure enough time for validation testing. The request was in the form of an Amendment Letter to the Commission. The extension of six month was granted and validation tests in fresh water were run in 2008.
WP5	Innovation Related Activities	None	None required
WP6	Consortium Management	None	None required
WP7	Project Management	Delay in obtaining Audit Certificates within the 45 day deadline for the Period 2 report	A request of 45 day extension was submitted and granted on Period 2 report

2.4 Work package deliverables update

Deliverable no.	Deliverable title	Date	Nature	Dissemination level	Resp. partner	Responsible Person(s)	Status	Comments
D1.1	**Task 1.1 Deliverables:** Reference document identifying specific requirement with regards to specific species (salmon, trout, sea bass and sea bream) in the different phases of their life-cycle.	6	R	PU	TI	Leif Arne Nygård David Fletcher	Done	Delivered as Appendix 2 to Activity Report in Period 1 report
D1.2	**Task 1.2 Deliverables:** Reference document describing the stability of different sizes of micro-bubbles in salt and freshwater.	7	R	CO	TI	Lene Beadle	Done	Delivered as Appendix 3 to Activity Report in Period 1 report
D1.3	**Task 1.3 Deliverables:** Reference document identifying water flow current and water flow in aquaculture tanks.	6	R	CO	GUT	Mirosław Grygorowicz Andrzej Rogalski Lech Rowiński	Done	Delivered as Appendix 4 to Activity Report in Period 1 report
D.2.1	**Task 2.1 Deliverables:** A prototype of the oxygen gas diffuser	10	P	CO	Pera	Andrew Geary	Done	Delivered as Appendix 5 to Activity Report in Period 1 report
D.2.2	**Task 2.2 Deliverables**: A prototype of the multi sensor for TOC, CO2, oxygen and total nitrogen.	12	P	CO	Pera	Chloe Hunt Lene Beadle Andrew Geary Victor Fiveland Natalie Julegina Peter Bundsgaard Lech Rowinski	Done	Delivered as Appendix 6 to Activity Report in Period 1 report Final D2.2 delivered as part of Reporting for Period 2
D.2.4	**Task 2.4: Deliverables:** Functional test report	14	R	CO	Pera	Andrew Geary	Done	A draft report was delivered as Appendix 7 to Activity Report for reporting of Period 1. A final report for this task was delivered as part of the reporting for Period 2.
D 2.5	**Task 2.5: Deliverables:** Report with assessment of risks (technical, economic and commercial), decision about contingency planning	14	R	CO	Pera	Andrew Geary	Done	A report for this task was delivered as part of the reporting for Period 2.

D.3.1	**Task 3.1 Deliverables:** A prototype of the water stream generator	10	P	CO	GUT	Mirosław Grygorowicz Lech Rowiński	Done	Delivered as Appendix 8 to Activity Report in Period 1 report
D.3.2	**Task 3.2 Deliverables**: Integrated prototype with water flow meters – development of algorithms.	11	P	CO	GUT	Mirosław Grygorowicz Lech Rowiński	Done	Delivered as Appendix 9 to Activity Report in Period 1 report
D.3.3	**Task 3.3 Deliverables:** Integrated prototype in PE tank.	13	R	CO	GUT	Mirosław Grygorowicz Lech Rowiński	Done	Delivered as Appendix 10 to Activity Report in Period 1 report
D.3.4	**Task 3.4: Deliverables:** Functional test report	14	R	CO	GUT	Mirosław Grygorowicz Lech Rowiński	Done	Draft report delivered as Appendix 11 to Activity Report or the reporting for Period 1. A final report has been enclosed with the reporting for Period 2.
D 3.5	**Task 3.5: Deliverables:** Report with assessment of risks (technical, economic and commercial), decision about contingency planning	14	R	CO	GUT	Lech Rowinski	Done	A final report has been enclosed with the reporting for Period 2.
D.4.1	**Task 4.1 Deliverables:** Integrated pilot plant, test of a pilot plant with respect to treatment of aquaculture tank with control water quality parameters.	17	P	RE	TI	Victor Fiveland Trond Johannessen Lene Beadle Sheila Kvindesland Peter Bundsgaard	Done	Delivered as part of the reporting for Period 2
D.4.2	**Task 4.2 Deliverables**: Successful demonstration, to the project partners, of up to 8 industrial case study including installation and testing in fish farming plants for salmon, trout, sea bass and sea bream. Cost analyses of integrated system both with regards to investment and running costs. Comparing with conventional oxygenation equipment.	24	R	PP	TI	Victor Fiveland Sheila Kvindesland Lene Beadle	Done	Delivered as part of the reporting for Period 2
D.5.1	**Task 5.1 Deliverables:** A report on potentially competitive patents and a plan for patent application(s) if	24	R	CO	Plastsveis	Victor Fiveland Lene Beadle	Done	Delivered as part of the reporting for Period 2

	required with exploitation agreements between the partners.							
D.5.2	**Task 5.2 Deliverables**: Production of support material for transfer of the knowledge to the partners through case studies and a generic design guide.	24	O	PU	Plastsveis	Victor Fiveland Sheila Kvindesland	Done	Delivered as part of the report for Period 2
D.5.3	**Task 5.3 Deliverables:** 2 papers presented at conferences and major exhibitions and production of 2 publications in the form of editorials, technical papers and trade press.	24	O	PU	Plastsveis	Victor Fiveland Sheila Kvindesland Lene Beadle	Done	Delivered as part of the report for Period 2
D.5.4	**Task 5.4 Deliverables:** A report on the standards, ethical and regulatory aspects of the exploitation of the results	24	R	CO	Plastsveis	Sheila Kvindesland	Done	Delivered as part of the report for Period 2
D.5.5	**Task 5.5 Deliverables:** Relevant companies contacted directly to promote the project results and stimulated to apply or use the results in their future product strategy.	24	O	PU	Plastsveis	Plastsveis	Done	Delivered as part of the report for Period 2
D6.1	**Task 6.1 Deliverables:** Delivery of an initial and complete Plan for Using and Disseminating Knowledge. Delivery of patent applications if applicable	12, 24	R	CO	Plastsveis	Trond Johannesen	Done	Draft delivered as Appendix 12 to Activity Report in Period 1 report. Final PUD enclosed as part of the reporting for Period 2

R = Report
P = Prototype
D = Demonstrator
O = Other

PU = Public
PP = Restricted to other plan participants (including the Commission Services)
RE = Restricted to a group specified by the consortium (including the Commission Services)
CO = Confidential, only for members of the consortium (including the Commission Services)

2.5 Work package milestones update

Milestone No	Work Package No.	Milestone Name	Date Due	Date competed	Lead Contractor
1	1	Scientific Understanding of aquatic environment in aquaculture tanks	July2006	July 2006	7
2	1	Scientific understanding of creation of and stabiligy of micro-bubbles	Jully 2006	July 2006	7
3	2	Prototype of oxygen gas diffuser	October 2006	June 2006	7
4	3	Prototype water stream generator	October 2006	August 2006	9
5	2	Integration of oxygen gas diffuser including development of software and algorithms.	January 2007	May 2007	8
6	3	Integration of water stream generator with water flow meter including development of software and algorithms	January 2007	Integration – August 2006	9
7	4	System Integration	July 2007	May 2007	7
8	4	Industrial validation	June 2008	June 2008	7

2.6 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	23-29	30
1.0	**Scientific Understanding**	**7**	**7**																								
1.1	Aquatic environment different species	6	6						●																		
1.2	Creation of micro-bubbles	7	7							●																	
1.3	Water flow and current	9	6						●																		
2.0	**Develop low pressure oxygen generator**	**8**	**14**																								
2.1	Oxygen gas diffuser	7	10										●														
2.2	Multisensor	8	12												●												
2.3	Integration – build prototype	8	13																								
2.4	Functional tests	7	14														●										
2.5	Risk assesment	7	14														●										
3.0	**Develop water stream generator**	**9**	**14**																								
3.1	Water stream generator	10	10										●														
3.2	Integration with water flow meters	11	11											●													
3.3	Integration in PE tank	1	13													●											
3.4	Functional test	9	14														●										
3.5	Risk asessment	9	14														●										
4.0	**System Integration & Validation**	**7**	**30**																								
4.1	System Integration	7	17																	●							
4.2	Industrial Validation	7	30																								●
5.0	**Innovation Related Activities**	**1**	**30**																								
5.1	Protection of IPR	1	30																								●
5.2	Absorption of results by proposers	1	30																								●
5.3	Dissemination of knowledge	1	30																								●
5.4	Socio-economic aspects	12	30																								●
5.5	Promotion of exploitation	1	30																								●

SECTION 3 – OTHER ISSUES

3.1 Dissemination

Information about the ongoing IntelFishTank project has been given at several gatherings of people in the fish farming sector, including the specific arrangements shown in the table below:

Planned/actual dates	**Type**	**Type of audience**	**Countries Addressed**	**Size of Audience**	**Partner responsible / involved**
September 2006	Poster and info brochures at IWA World Water Congress and Exhibition	Key decision-makers and top professionals from the fields of water and environment	Worldwide	> 3000	TI
May 2006	Poster and info brochures at Aqua 2006 Exhibition, Florence, ITA.	Delegates in the marine sectors from all over the world	Worldwide	> 3000	Plastsveis, Aswega, TI, Pera
April 2006	Poster and info brochure at Norway Fish & Aqua International 2006	Professionals in the field of Aqua Culture	Europe	> 7000	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[1]	TI/All
November/December 2007	Article featured in Hatchery International	Aquaculture Industry	Worldwide	10 500**Error! Bookmark not defined.**	Artec Aqua AS
April 2008	Article featured in Norsk Sjomat	Aquaculture Industry	Norway		TI
Currently	Marketing of Variostreamer on company web page	All interested parties	Worldwide	-	Artec Aqua AS
September 2008	Convention	Norwegian aquaculture industry	Norway	110	Artec Aqua AS

The project website (www.intelfishtank.com) has been set up.

[1] http://www.nor-fishing.no/messe.php?messe=12

3.2 Overall Contributions of Consortium

The project consortium has gathered 5 SMEs, 2 LE and 3 RTDs with complementary skills. The structure built up to carry out the project was critical to reach our goals due to the particularities of the final products to be developed.
For the successful completion of the project the complete value chain was involved in the consortium:

- Oxygen Gas Diffuser Development: Plastsveis / Artec
- Water Streamer Generator: Plastsveis / Artec
- Pump Technology: Tsurumi
- Sensor and Control Technology: Oxymat, Aswega, Artec
- System Validation: Fjord, PanFish, Aswega, Oxymat, Tsurumi, Plastsveis, Artec

TI, GUT and Pera as RTD Performers participated in nearly all technical tasks since they have the capabilities to support SMEs in the development of all technical aspects necessary for the success of the project:

- Defining specific oxygen and other water parameter requirements with regards to different species to be used as design criteria for development of the oxygen gas diffuser (TI)
- Describing scientific understanding of formation, gas exchange, coagulation and other factors of micro bubbles in saline and fresh water to be used as foundation for development of the oxygen gas diffuser (TI)
- Identifying water flow current and water flow in aquaculture tanks to be used as foundation for development of the water stream generator (GUT)
- Work on design and choice of material for development of oxygen gas diffuser (Pera)
- Water streamer development – design and algorithm (GUT)
- System integration and industrial verification of product prototype and full scale testing to verify that product do meet set project requirements (TI, Pera, GUT)
- Dissemination of technology and results towards the aquaculture sector (TI, Pera and GUT)
- Innovation related activities (TI, Pera, GUT)

The table below gives information of needed expertise in the work packages dealt with in Period 2, from January 1st, 2007 to June 30th, 2008, as well as which partners have provided the needed expertise.

Work Package		Personnel: Expertise needed in	Provided by
WP 2	Build prototype of multi sensor	Sensor technology Software technology Design and engineering	Oxymat, Pera, Plastsveis, Artec, Aswega, GUT, TI
	Functional test of oxygen gas diffuser	Design and engineering	Plastsveis, Artec, Pera, TI
WP 3	Functional Test Report	Design and engineering	Plastsveis, Artec Tsurumi, Aswega, GUT, TI, Pera
WP 4	System Integration	Engineering Software Sensor Technology Manufacturing	Plastsveis, Artec, Aswega, Oxymat, Marine Harvest, TI, Pera, GUT
	System validation	Software Lab-work Scientific Evaluation	Plastsveis, Artec, Marine Harvest, TI
WP 5	Patent Applications	Engineering	Artec/Plastsveis
	Support Material	Software Design Mehcanical Sesor Technology	All
	Papers & Publications	Marketing	Artec/Plastsveis, TI
	Standards, Technical & Regulatory Aspects	Regulatory insight Technical	TI
	Promotion of project results	Marketing	All
WP 6	Dissemination and exploitation of results	Gather reliable information of exploitation routes Web design	All