



**European Cooperation
in the field of Scientific
and Technical Research
- COST -**

Secretariat

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COST 219/08

MEMORANDUM OF UNDERSTANDING

Subject : Memorandum of Understanding for the implementation of a European Concerted Research Action designated as COST Action FA0801: Critical success factors for fish larval production in European Aquaculture: a multidisciplinary network (LARVANET)

Delegations will find attached the Memorandum of Understanding for COST Action FA0801 as approved by the COST Committee of Senior Officials (CSO) at its 171st meeting on 18-19 June 2008.

MEMORANDUM OF UNDERSTANDING

For the implementation of a European Concerted Research Action designated as

COST Action FA0801

CRITICAL SUCCESS FACTORS FOR FISH LARVAL PRODUCTION IN EUROPEAN AQUACULTURE: A MULTIDISCIPLINARY NETWORK (LARVANET)

The Parties to this Memorandum of Understanding, declaring their common intention to participate in the concerted Action referred to above and described in the technical Annex to the Memorandum, have reached the following understanding:

1. The Action will be carried out in accordance with the provisions of document COST 270/07 “Rules and Procedures for Implementing COST Actions”, or in any new document amending or replacing it, the contents of which the Parties are fully aware of.
2. The main objective of this Action is to contribute to the improvement of the scientific knowledge base, which underlie the development of a sustainable European aquaculture, through the development of tools for predicting juvenile fish quality.
3. The economic dimension of the activities carried out under the Action has been estimated, on the basis of information available during the planning of the Action, at EUR 13 million in 2007 prices.
4. The Memorandum of Understanding will take effect on being accepted by at least five Parties.
5. The Memorandum of Understanding will remain in force for a period of 4 years, calculated from the date of the first meeting of the Management Committee, unless the duration of the Action is modified according to the provisions of Chapter V of the document referred to in Point 1 above.

A. ABSTRACT AND KEYWORDS

Sustainable growth of the European aquaculture industry requires an improved knowledge basis that allows a predictable supply of high quality juvenile fish for the grow-out phase and up to the consumers' standards. Relatively low survival rates and sub-optimal quality are largely attributed to uncontrolled problems during larval rearing, and lack of tools for early prediction of larval phenotype and quality.

There are over 100 universities, colleges and research institutions in Europe involved in aquaculture, as well as an equal number of research institutions. Currently the European aquaculture industry produces about 1.3 million tonnes of fish, equal to one third of the EU fishery value. The aim of this COST Action is to contribute to the scientific knowledge basis as to support a sustainable development of aquaculture. This requires identifying critical success factors and gaps in knowledge in order to overcome the present limiting predictable mass supply of quality juveniles. The multidisciplinary network of researchers and producers intends to achieve this through integration of knowledge obtained in national and European research projects and practical experience. This Action will contribute to a better understanding of fish larval physiology, identify quality and performance predictors for larval-juvenile production and enhance a rapid development of improved production protocols and hatchery management procedures.

Keywords: juveniles production for aquaculture, fish larvae, nutrition, disease control, quality indices

B. BACKGROUND

B.1 General background

Sustainable growth of the European aquaculture industry requires high numbers of healthy fish larvae. Despite considerable progress in European aquaculture in the past 20 years, e.g. with production of over 1 billion fry of seabass and seabream in 2007, high mortalities during larval production and variable fry quality still plague the industry. This is exacerbated by an increasing need for diversification into new species, where these problems are even more acute.

Therefore, there is still a significant amount of work to do to make the industry more cost-effective and sustainable. The lack of a predictable supply of high quality fish juveniles is largely attributed to uncontrolled environmental and nutritional factors during the larval rearing as well as the lack of tools for early prediction of larval phenotype, performance and quality. There is thus a clear need for an improvement of the scientific knowledge basis that will support sustainable development of aquaculture. More recently, the well-documented environmental impact of factors such as climate change, on fish production will place even greater demands on the application of an integrated-multidisciplinary approach to improve larval performance and juvenile quality in the European aquaculture industry.

Maximizing fish production requires in-depth knowledge of mechanisms, both biological and abiotic, which affect the developing organism prior to reaching the grow-out farms. First feeding diets given to larvae have been identified as a determining factor for the juvenile phenotype in a number of species. Various nutrients act on gene regulation of major physiological functions and thus should be an important feature of stage- and species-specific diet formulation but this has been largely ignored so far. While waterborne components such as endocrine disruptors have been well investigated for their effects on fish reproduction, there is almost no investigation into their effects on the larval-juvenile transition despite the well-documented importance of hormones in this process. The integration of molecular, nutritional and morpho-physiological results is of paramount importance, as the influences on juvenile fish quality are multifactorial.

A larval fish research network is necessary to facilitate international cooperation, exchange of scientists and students, and efficient use of resources at all levels, as well as exercising a lobby to influence long-term policy. There are over 100 universities and research institutions in Europe involved in aquaculture. Currently the European aquaculture industry produces about 1.3 million tonnes of finfish, equal to one third of the EU fishery market value, although representing only 20% of its volume. A forum for constructive dialogue between stakeholders and researchers would directly build the know-how necessary to promote sustainable development and competitiveness at a basic level - ability to produce cost-effectively quality juveniles.

B.2 Current state of knowledge

There is still very little knowledge on basic fish larval biology. This includes how external (environmental) and internal (molecular/ developmental/ physiological/ behavioural/ genetic)

factors interact in defining the phenotype and quality of fish larvae and juveniles. Acquiring this knowledge will require a collation of fundamental and comparative studies on the importance of broodstock genetics and husbandry, water quality, larval nutrition and feeding, growth physiology, health, metamorphosis, underlying molecular mechanisms for development, larval behaviour and environmental conditions.

Zebrafish is used as a model species in understanding fundamental biological and molecular mechanisms of vertebrate development. However, zebrafish are not representative of aquaculture species in terms of growth potential. Other possible model fishes include seabass, seabream and cod. For the investigation of metamorphosis in turbot, sole and halibut may be suitable model species. All these species are of major interest to the European aquaculture industry. Salmonids such as salmon and trout, though of major importance, do not suffer from the same quality problems because they hatch at an advanced developmental stage.

The importance of individual variation has also been outlined. The use of high throughput molecular methods may be useful in this respect but can be limited by the low funding investment in fish, and large-scale genomic resources are required. The funding of multinational consortia should be further encouraged. More studies on genotype/ phenotype/ selection are required to understand how these relate to quality and viability. Coordination of such activities at European levels through a COST Action will certainly help in making an effective pan-European effort in these endeavours.

Effects of broodstock nutrition on egg quality and larval production. Maternal effects on the outcome of larval fish production have been little studied. Egg quality can be influenced by broodstock nutrition. During the spawning season, one female can spawn eggs equivalent to 1-1.5 times their own weight. Obviously, broodstock has a requirement for a very nutritious diet.

Therefore, specialised broodstock diets should be developed to maximise the nutrient content of the eggs, and hence egg and larval quality. Also, the extensive knowledge available on egg quality in farmed land animals and humans can potentially be applied to fish. The degree of inbreeding in broodstock may also be responsible for causing larval-fry deformities. Genetic approaches may help in establishing to what extent inbreeding of broodstock may be a problem in European aquaculture.

Causes of mortality in fish larvae. High mortalities (over 70%) are still a reality when farming marine fish larvae. Although broodstock quality and nutrition, larval nutrition, physical damage,

microbial ecology and presence of pathogenic organisms are likely key factors, their relative importance is still largely unknown.

Causes of fast and slow growth in a given larval batch. The relative numbers of slow and fast growers between batches of fish larvae is a matter little studied. However, this is of major significance for commercial hatcheries. Fast growers may be preferred to increase productivity, but slow growers may be more resilient to stress and disease. Growth dispersion may result in cannibalism in some species and will increase operational costs of grading procedures. The differential growth in a given batch depends on genetic factors, but also on zootechnical conditions. In fact, hydrodynamics and food/prey availability can probably be used to influence the relative number of slow and fast grower larvae of a given batch, and thus a more reproducible outcome between batches.

Ontogeny of the digestive function and resulting constraints in diet composition. There is still a very poor knowledge of basic physiological mechanisms and responses to dietary variations in fish larvae. Deeper understanding of the digestive ontogeny and processes is needed in light of the fact that fish larvae may increase their weight by 16,000% in one month from hatching (Senegalese sole). While larval digestive capacity and timing of development of digestive organs have been well studied, very little is known about the absorptive process or about interactions between different mechanisms and phases of larval digestive physiology, such as interactions between ingestion/satiety, gut transit rate, digestion and absorption, as well as their regulation by post-absorptive mechanisms. A better understanding of basic physiological processes in response to different diets is essential in designing formulated diets for first-feeding larvae. More integrated approaches that include classical zootechnical and biochemical studies together with newer approaches based on molecular biology and functional genomics will lead to important progress in the field.

Skeletal development regulation and requirements in relation to abnormalities. The development of complex structures such as the skeleton, are under control of a complex web of genes expressed at very precise points, which triggers a cascade of events that determine the final shape of the fish. The skeletal problems can affect the majority of reared fry, leading to decreased growth, survival and quality of fry. In addition, there is the need for manual sorting and elimination of deformed fish. The causes already identified include genetics, hydrodynamic conditions, nutritional deficiencies, toxic substances, all leading to disruption of the cellular machinery

responsible for mineral uptake and deposition. A more profound approach to the relationships between environment, nutrition and genetics and the identification of all hormonal and genetic signals involved along with progresses on zootechnical conditions may produce improvements in fish quality and aquaculture revenues.

Environmental impact on developmental ontogeny and viability. The larvae live in water, whose characteristics (temperature, salinity and oxygen, as well as nutrients and microbial loading) play profound roles in the fish development. So for instance, temperature has been demonstrated to be associated with sex determination, abnormal bone development and the number of muscle fibres at hatch, determining the growth potential. Salinity has a great impact on development in stenohaline species. Adjusting the salinity for euryhaline species to physiological levels may improve conversion efficiency through reduced energy demand for osmoregulation. Further, light intensity can affect the circadian or circannual rhythm, feed intake and hence growth. The water is also a source for micronutrients. So for instance, an iodine deficiency will lower thyroid hormone levels involved in metamorphosis and development. These are only some of the environmental processes that are not fully understood and require elucidation.

Identification of key aspects of metamorphosis. Metamorphosis is a series of transitional events affecting the complete body structure and physiology of the developing larvae governed by a unique hormonal interplay where thyroid hormones have a leading role. Metamorphosis is accompanied by severe larval losses in hatcheries. Identifying the crucial aspects and rules governing these events, and the clarification of the associated endocrine processes, is essential to reduce losses and manipulate growth potential. All morphological, physiological and behavioural changes will only be properly completed if the larva gains sufficient energy and essential nutrients as well as avoids most stress inducing factors. Several of these factors are likely to be common for quite a few species but the levels (i.e. nutrients), timing (critical windows) and consequences (i.e. lack of eye migration in flatfish) will be different. Both a wide range of collaborations as well as species specific trials are required to unravel these aspects.

Identifying key events in the development of larval and juvenile immune systems. During larval development, the immune system undergoes rapid changes until it becomes fully functional. The innate defense mechanisms are predominant during these stages. It is becoming increasingly clear that the beneficial effects of substances which modulate the immune system result in improved fish survival upon pathogen exposure during the latter stages of development. There is little

information on the contribution of these immuno-modulators in the larval immune system.

Markers of fish larval and juvenile quality. It is very important to identify parameters, from industry and research, which can be used as predictors of fish larval and juvenile quality and integrate them into prediction matrices. As quality is market-specific, a broad range of such markers is sought. The quality of a juvenile fish is first confirmed after metamorphosis, after a long and often expensive production period. Therefore, it is valuable to identify factors which determine the quality of the fish early. Possible indices are physiological indices of stress response or tolerance; morphological indices; behavioural indices of phototaxy, activity levels, schooling and feeding rates; and immunological indices such as disease resistance. Their predictive value remains to be confirmed. Quality markers will also be required in the near future to allow the introduction of science-based certification schemes to add value to aquaculture products based on societal concerns with food safety, fish welfare and environmental sustainability.

Improved production protocols and hatchery management are vital for European aquaculture. Synthesizing the available information, formulating recommendations, and developing support tools are of primary interest to the main stakeholder groups: hatchery producers and on-growing farmers. The European way of production and science, with requirements of environmental sustainability and high labour costs, as well as social responsibility, relies on an effective integrated research effort. The research funding should reflect the vested interests. Unfortunately, the economic losses in fish production far outstrip the funds allocated to research on the causes of these losses.

B.3 Reasons for the Action

The aim of this COST Action is to contribute to the sustainable development of European aquaculture, through identifying critical success factors, and gaps in knowledge, that limit the predictable mass supply of quality juveniles. The multidisciplinary network of researchers and producers intends to achieve this through integration of knowledge obtained in national and European research projects and practical experience. This Action will identify quality predictors for larval-juvenile production and contribute to the rapid development of improved production protocols and hatchery management procedures. The COST Action is aimed at developing the European economy through an improved aquaculture industry that provides a healthy product for the well being of the European population.

Therefore, LARVANET aims at identifying the present problems in aquaculture that stem from the larval and juvenile stages through consultation with world and European experts, learn about these problems and propose topics for further focused research through national and European funds and finally come up with potential protocols to alleviate such problems.

To accomplish its objectives, the network plans to organize 4 thematic workshops, 2 training courses, at least 9 scientific publications and 6 technical publications. A public website will also be created for dissemination of activities and outcomes, and a password protected area will be included, in order to create an effective electronic communication network.

B.4 Complementarity with other research programmes

LARVANET plans to use its unique platform of joining industry and research in the area of larviculture to discuss industry bottlenecks for improved industrial performance. This platform will tie in with present and past European supported programs such as FINEFISH, which focuses on avoidance of larval-stage-based deformities in European aquaculture. It is worth stressing that at the moment there is no structure in place at a European level providing such a network between fish researchers and industry partners. This need is emphasized by the paucity of research activities on larval issues funded by FP5, FP6 and so far by FP7, restricting larval research to national funding, with poor international cooperation. This Action corresponds with one of the initiative areas within the European Aquaculture Technology Platform as proposed by commercial European aquaculture companies.

C. OBJECTIVES AND BENEFITS

C.1 Main/primary objectives

The main objective of this Action is to contribute to the improvement of the scientific knowledge base, which underlie the development of a sustainable European aquaculture, through the development of tools for predicting juvenile fish quality. This would in turn increase profitability, employment security, and ultimately lower production costs, which can be passed on to the consumer. These societal benefits will derive from advances in the understanding of the biological mechanisms determining fish larval performance, identification of quality markers and technical advances in production technologies.

C.2 Secondary objectives

1. To review the current state of knowledge related to different key areas of fish larvae research (WG1). The focus will be on the major farmed fish species in Europe (seabream, seabass, turbot, cod, sole, halibut, carp), but knowledge on other species will also be used.
2. Based on the above review of current knowledge it is intended to identify critical success factors, and related gaps in the scientific knowledge, limiting predictable mass supply of quality juveniles for the European aquaculture industry (WG1).
3. To propose research projects to address gaps in the scientific knowledge, which require additional funding (WG1).
4. To identify biological parameters which can be applied (in vivo or post hoc) as predictors of fish larvae and juvenile quality (WG2).
5. To integrate the preceding information, involving researchers but also fish farmers and other stakeholders, to develop matrices predicting phenotype and larval quality (WG2).
6. To test the developed phenotype and larval quality predicting matrices, through: (a) collaborative Action within the framework of the COST, if necessary using short term scientific missions; and (b) preparation of joint research projects proposals where additional funding is required (WG2).
7. Layout the principles of a database of fingerling quality available from different sources in Europe as a tool for farmers to select the best fingerlings for their set constraints and environmental conditions (WG2 and WG3).
8. To synthesize the information on critical success factors limiting predictable mass supply of quality juveniles, and operational predictors of fish larvae and juvenile quality, and make it available to the main stakeholder groups - hatchery producers and their client on-growing farmers (WG3).
9. To validate, at industrial scale, the developed phenotype and larval quality predicting matrices (WG3).

10. To propose monitoring systems and protocols to assess larval quality and predict juvenile phenotype in commercial hatcheries, and assess the possibility of developing ISO standards for the European larviculture industry (WG3).
11. To discuss strategies for dissemination of the network findings and outcomes, and promote dissemination activities (WG3).
12. To facilitate the communication between ongoing projects, and other initiatives, at a national and international level.
13. To facilitate knowledge transfer and training, in particular for early stage researchers, through training schools and short scientific missions between the research groups involved in the project, while promoting a pan-European interaction.

C.3 How will the objectives be achieved?

This Action contributes to the sustainable development of European aquaculture, through identifying critical success factors, and gaps in knowledge, limiting predictable mass supply of quality juveniles. This will be accomplished through a multidisciplinary network of researchers and producers willing to integrate knowledge obtained in national and European level research projects, practical experiences, and basic knowledge on fish larvae physiology and molecular biology. Finally, this network should identify quality predictors for larval production and contribute to the development of economically- and environmentally sustainable production protocols and hatchery management procedures.

C.4 Benefits of the Action

This COST Action brings together a very diverse group both in technical and geographical terms, which includes most of the European internationally recognized researchers and technical experts in the field of fish larvae research. These researchers complement one another in the scientific area of expertise, experience with different fish species, and scientific/technical perspectives. This COST Action should therefore create a momentum to gain new insight into larval physiology and into some of the problems plaguing larval production for several years, and which have only been partly solved by small scale projects at national and European levels.

This COST Action will also facilitate the coordination of activities of researchers at a European

level, including training of early stage researchers, and directly benefit sustainable development of aquaculture.

C.5 Target groups/end users

This COST Action will benefit all stakeholders involved in European aquaculture. Through synthesis of available information, formulation of recommendations, and development of support tools for decision making concerning fish juvenile quality, the main stakeholder groups: hatchery producers and their client on-growing farmers will benefit Governmental agencies, Universities and other research institutions, which will also have major advantages since coordination of research efforts will be facilitated and gaps in knowledge identified. In this respect, the COST Action can serve as a platform and network of contacts at European level to launch research projects and other initiatives within the European Research Area. The European consumer will also take advantage from this COST Action as the benefits to the European aquaculture industry will likely be reflected, in the long term, in fish products of better quality at a more competitive price.

D. SCIENTIFIC PROGRAMME

D.1 Scientific focus

This coordinated Action will pioneer the integration of a broad range of multidisciplinary research activities in fish larvae in order to improve the scientific knowledge base that allows for better understanding of nutritional and environmental effects on fish larvae physiology, development and performance, therefore supporting the need for predictable mass supply of quality juvenile fish throughout Europe. It will bring together research groups, industry representatives and a wide range of stakeholders involved in fish farming.

The integration of knowledge obtained in national and European larval fish research projects and practical experience will be a key issue. Finally, quality predictors for larval production will be identified, to contribute to the development of production protocols and hatchery management procedures.

D.2 Scientific work plan – methods and means

This COST Action activities will be organized based on three Working Groups

WG1: Basic knowledge on fish larvae biology

This Working Group will study the interaction between external (environmental, nutritional) and internal (molecular/ physiological/ behavioural/genetics) factors defining the phenotype and quality of fish larvae and juveniles. This will require a critical collation of fundamental and comparative knowledge on the importance of e.g. broodstock genetics and selection, broodstock husbandry and nutrition, water quality (chemical and microbiological), larval nutrition and feeding, growth physiology, health and immunology, metamorphosis, underlying molecular mechanisms for development and homeostasis, larval behaviour, and environmental conditions.

The objectives of WG1 are:

1. To review the current state of knowledge related to fish larvae in the following key areas:
 - 1) Effects of broodstock nutrition and egg quality on larval production;
 - 2) Ontogeny and its impact on larval and juvenile viability and quality;
 - 3) Environmental causes of mortality in fish larvae: water quality, microbiology and larval health;
 - 4) Ontogeny of the digestive function and resulting constraints in diet composition;
 - 5) Regulation and dietary requirements in relation to skeletal and other abnormalities;
 - 6) key aspects of metamorphosis: timing, and underlying molecular mechanisms for development, and importance for larval quality.
2. The focus will be on the major farmed species in Europe (seabream, seabass, cod, turbot, sole, halibut, carp), but knowledge on other species will also be used.
3. To identify critical success factors, limiting larval survival and predictable mass supply of quality juveniles for the European aquaculture industry.
4. To identify gaps in the scientific knowledge concerning the above information.
5. To identify short-term scientific missions within the research network to address the identified gaps using available resources.
6. To promote the organization of training schools for young researchers on mass rearing of quality juveniles for aquaculture.
7. To propose research projects to address gaps, which require additional funding.

Deliverables for WG1:

- 7 Literature reviews on fundamental biological knowledge relevant to larval research and determining larval phenotype and quality.
- Report on critical success factors limiting predictable mass supply of quality juveniles for the European aquaculture industry.
- Report identifying gaps in the scientific knowledge and the further research needs in each area.
- 20 Short scientific missions.
- Joint research proposals.
- 5 Technical/scientific workshops.
- 2 Training schools for young researchers.

Milestones for WG1: Month 3: Starting up workshop is organized

Month 3: Working groups formed (new incomers after that will be welcome)

Month 12: Scientific workshop is organized. Main theme: Current state of knowledge in fish larvae research; Available indicators of quality for fish larvae and juveniles.

Month 12: Structure of literature reviews on relevant fundamental biological knowledge is defined, and type of aimed publication is also discussed and agreed.

Month 12: First training school for young researchers is completed.

Month 24: Literature reviews on relevant fundamental biological knowledge are completed and submitted for publication.

Month 24: Scientific workshop is organized. Main themes: Fundamental biological knowledge defining the phenotype and quality of fish larvae and juveniles; Critical success factors limiting predictable mass supply of quality juveniles for the European aquaculture industry.

Month 24: Structure of report on critical success factors limiting predictable mass supply of quality juveniles is defined.

Month 24: Structure of report identifying the further research needs in each area is defined.

Month 32: Second training school for young researchers is completed.

Month 36: Scientific workshop is organized. Main theme: Critical success factors limiting predictable mass supply of quality juveniles

Month 36: Report on critical success factors limiting predictable mass supply of quality juveniles is completed.

Month 36: Report identifying the further research needs in each area is completed.

Month 48: Scientific workshop is organized. Main themes: Fundamental biological knowledge defining the phenotype and quality of fish larvae and juveniles; Critical success factors limiting predictable mass supply of quality juveniles.

WG2: Quality indicators for larval production

This Working Group will identify parameters, based on individual and collated experiences from industry and research members, which can be used as predictors of fish larvae and juvenile quality and integrate them into prediction matrices.

The objectives of WG2 are:

1. To identify biological parameters which can be applied (in vivo or post hoc) as predictors of fish larvae and juvenile quality.
2. To integrate the preceding information, involving researchers but also fish farmers and other stakeholders, to develop matrices predicting phenotype and larval quality.
3. To test the developed phenotype and larval quality predicting matrices, through:
(a) collaborative Action within the framework of the COST, if necessary using short term scientific missions; and (b) preparation of joint research projects proposals where additional funding is required.
4. Layout the principles of a database of fingerlings quality available from different sources in Europe as a tool for farmers to select to the best fingerlings for their set constraints and environmental conditions.

Deliverables for WG2:

- o Report on biological parameters and suitable matrices to be used as predictors of phenotype and larval quality in production of juvenile fish for aquaculture.

- Report on the testing of the developed phenotype and larval quality predicting matrices.
- Report identifying the further research needs on predictors of phenotype and larval quality in production of juvenile fish for aquaculture.
- Prototype of database of fingerling quality available from different sources in Europe
- 5 Technical/scientific workshops.

Milestones for WG2:

Month 3: Organize start up workshop

Month 3: Working group formed (new incomers after that will be welcome)

Month 12: Technical/scientific workshop is organized. Main theme: Biological parameters to be used as predictors of phenotype and larval quality in production of juvenile fish for aquaculture.

Month 12: Structure of report on biological parameters and suitable matrices to be used as predictors of phenotype and larval quality in production of juvenile fish for aquaculture is defined.

Month 24: Report on biological parameters and suitable matrices to be used as predictors of phenotype and larval quality in production of juvenile fish for aquaculture is completed.

Month 24: Technical/scientific workshop is organized. Main theme: Biological parameters to be used as predictors of phenotype and larval quality in production of juvenile fish for aquaculture.

Month 24: Structure of report on the testing of the developed phenotype and larval quality predicting matrices is defined.

Month 36: Report on testing of the developed phenotype and larval quality predicting matrices is completed.

Month 36: Technical/scientific workshop is organized. Main theme: Matrices of biological parameters to be used as predictors of phenotype and larval quality in production of juvenile fish for aquaculture;

Month 36: Structure of prototype of database of fingerling quality available from different sources in Europe is discussed and defined.

Month 36: Structure of report identifying the further research needs on predictors of phenotype and larval quality in production of juvenile fish for aquaculture is defined.

Month 48: Report identifying the further research needs on predictors of phenotype and larval quality in production of juvenile fish for aquaculture is completed.

Month 48: Prototype of database of fingerling quality available from different sources in Europe is completed.

Month 48: Technical workshop is organized. Main theme: Prototype of database of fingerling quality available from different sources in Europe

WG3: Improved production protocols and hatchery management

This Working Group will synthesize the information arising from WG1 and WG2 of primary interest to the main stakeholder groups: hatchery producers and their client on-growing farmers. It should formulate recommendations, and support tools for improved production protocols and hatchery management in European aquaculture.

The objectives of WG3 are:

1. To interact with WG1 and WG2 in defining what kind of information is of practical importance for the industry.
2. To synthesize the information arising from WG1 and WG2 of main interest to the main stakeholder groups.
3. To validate the developed phenotype and larval quality predicting matrices (WG2).
4. To propose monitoring systems and protocols to assess larval quality and, predict juvenile phenotype in practical conditions (commercial hatcheries), while promoting best management practices, and assessing the possibilities for developing ISO standards for the European larviculture industry.
5. To discuss strategies and implement dissemination of the network findings and outcomes, and promote dissemination activities.

Deliverables for WG3:

- Summary report on operational predictors of phenotype and larval quality in production of juvenile fish for aquaculture.
- Report on data collecting systems and protocols to facilitate assessment of larval phenotype and larval quality in commercial hatcheries.
- Technical workshops.

Milestones for WG3:

Month 3: Start up workshop is organized

Month 3: Working group formed (new incomers after that will be welcome)

Month 12: Technical workshop is organized. Main theme: Operational predictors of phenotype and larval quality in production of juvenile fish for aquaculture.

Month 12: Structure of preliminary report on data collecting systems and protocols to facilitate assessment of larval phenotype and larval quality in commercial hatcheries is defined.

Month 24: Preliminary report on data collecting systems and protocols to facilitate assessment of larval phenotype and larval quality in commercial hatcheries is completed.

Month 24: Structure of final report on data collecting systems and protocols to facilitate assessment of larval phenotype and larval quality in commercial hatcheries is defined.

Month 24: Technical workshop is organized. Main theme: Data collecting systems and protocols to facilitate assessment of larval phenotype and larval quality in commercial hatcheries.

Month 24: Structure of report on the testing of the developed phenotype and larval quality predicting matrices is defined.

Month 36: Report on data collecting systems and protocols to facilitate assessment of larval phenotype and larval quality in commercial hatcheries is completed.

Month 36: Technical workshop is organized. Main theme: Collecting systems and protocols to facilitate assessment of larval phenotype and larval quality in commercial hatcheries.

Month 36: Structure of summary report on operational predictors of phenotype and larval quality in production of juvenile fish for aquaculture is defined.

Month 48: Summary report on operational predictors of phenotype and larval quality in production of juvenile fish for aquaculture is completed.

Month 48: Technical workshop is organized. Main theme: Operational predictors of phenotype and larval quality in production of juvenile fish for aquaculture.

E. ORGANISATION

E.1 Coordination and organisation

This COST Action will respect all organizational features described in the "Rules and Procedures for Implementing COST Actions" (doc. COST 299/06). The organization of the Action will be based on a Management Committee (MC) and three Working groups (WG). In addition, a Scientific Committee (SC) will be established.

Management Committee:

- Election of COST Action Chair, Vice-Chair, Working Group Leaders, and Scientific Committee.
- Planning of Management Committee meetings.
- Planning of Technical/Scientific Workshops and Meetings.
- Evaluation of progress reports by the different Working Groups, in relation to meeting their objectives, and monitoring of their milestones.
- Preparation of the Annual Reports.
- Approve the allocation of resources to different activities, including early budgets, in order to maximize the impact of the COST Action, and meet the main objectives, through promotion of a good balance of activities (meetings, workshops, training schools, STSMs, publications, reports, etc.).
- Coordination of work between the different Working Groups, in order to fulfil the Action objectives and promote a good balance of participation of researchers, industry representatives and other stakeholders in the different activities.
- Promotion and approval of Short-Term Scientific Missions and training schools, according to the recommendations of the Scientific committee.
- Set-up and updating of a public Web site for dissemination of LARVANET activities, and internal communication.

- Promote contacts and common events with the appropriate ongoing COST Actions and other relevant national, European and international initiatives (e.g., EU projects, EATP platform).

Working group leaders:

- Planning of specific WG activities, including Scientific/technical Workshops and Meetings.
- Coordination of Working Group activities, in relation to the WG objectives.
- Preparation of WG progress reports to the Action Chair and Management Committee.

Scientific Committee (SC)

- Advise Action chair, MC, and WG leaders in scientific/technical content of Workshops, meetings and other initiatives when required.
- Assist Action chair and MC in preparation of annual reports
- Advise MC on approval of Short-Term Scientific Missions and training schools.

The research groups ready to participate in this new COST Action represent a unique consortium of European researchers, industry and governmental body representatives, with extensive experience in their fields. The consortium of academic researchers and industrial partners has the necessary expertise, technical infrastructure and methodological know-how to successfully address the scientific, technical and dissemination aspects of this Action.

E.2 Working Groups

This concerted Action will be organized based on three Working Groups:

WG1: Basic knowledge on fish larvae biology

WG2: Quality indicators for larval production

WG3: Improved production protocols and hatchery management.

The main objectives, deliverables and milestones of each of the Working Groups are given in detail in section D.2. Each Working Group will have a leader and sub-leader. These in turn may appoint task leaders within the Work Group specific objectives in order to share workloads and increase work efficiency.

E.3 Liaison and interaction with other research programmes

This Action corresponds with one of the initiative areas within the European Aquaculture Technology Platform as proposed by commercial European aquaculture companies, and is actively linked up to the EATP network.

LARVANET will actively promote the sharing of information, and where possible promote joint activities, such as meetings, seminars and workshops, with other European research initiatives, such as:

- FINEFISH, a "collective research" Action "between SMEs and RTD groups" within the FP6 which focuses on the avoidance of larvae stage based deformities in European aquaculture.
- AQUA-TNET, the EU Socrates Erasmus thematic network in the field of aquaculture, fisheries and aquatic resources management. The network currently consists of 109 partners, representing universities, training organizations, associations and research performers.
- COST Action 867 Welfare of Fish in European Aquaculture, devoted to improve awareness and good fish welfare practices in European aquaculture.
- Marine Genomics Europe, a FP6 Network of Excellence devoted to the development, utilization and spreading of high-throughput approaches for the investigation of the biology of marine organisms, including farmed fish.
- TOTAL QUALITY IN REARED SEABASS AND SEABREAM [Validazione di indicatori morfo-fisiologici della filiera produttiva di spigola (*Dicentrarchus labrax*) ed orata (*Sparus aurata*) e modello di riferimento (su base coordinata) per la costruzione di un sistema esparto], a national research program funded by the Italian Ministry for Agriculture, Alimentary and Forestry Policy (6C144; Law 41/82) which focuses on the identification of multilevel quality descriptors at different phases of the production cycle in seabass and gilthead seabream.
- Development of a method for early identification of nutritional problems in larval fish based on behavioral observations. A Greek national project under the program Development of industrial research and technology.

- SEACASE, a FP6 STREP project promoting sustainable extensive and semi-intensive aquaculture in Southern Europe that includes the study of production methods for high quality fish fry.
- ECOCARP (EC INCO-DEV Research, Project Number ICA4-CT-2001-10024) with China: New native fish species for Asian aquaculture: conserving natural genetic reserves and increasing options for sustainable use of aquatic resources (ECOCARP).
- FishBase & LarvalBase, information systems on finfish, fish larvae and juvenile stages (World Wide Web Electronic publication. <http://www.larvalbase.org/>, www.larvalbase.org, www.fishbase.org).
- MACOM (EC-Project) Demonstration of maternal effects of Atlantic cod: Combining the use of unique mesocosm and novel molecular techniques.
- Light management: Novel narrow bandwidth lighting technology in cod farming and its impact on performance from early stages. A 4 years project funded by the Norwegian Research Council in collaboration with the Institute of Marine Research (IMR) and a lighting manufacturer.
- Cod broodstock nutrition; the role of arachidonic acid and astaxanthin as determinants of egg quality. A 2 year project funded by the Scottish Aquaculture Research Forum (SARF) from October 2005 to September 2007.
- Fatty acid and carotenoid content of Atlantic cod eggs from Scottish hatcheries: effects on egg and larval quality. A one year project funded by the Sea Fish Industry Authority (SFIA) from October 2007 to September 2008.
- PLEUROGENE - Flatfish genomics: enhancing commercial culture of Atlantic halibut and Senegal sole (project funded by Genome Canada-Genome Spain), this project developed gene libraries and microarrays for gene expression in biological processes including larval development and larval nutrition.
- Advances on the digestive capabilities in larvae and juveniles of marine fish. Characterization of the gene expression of enzyme precursors and of the intra-specific polymorphism of proteases. (National project funded by National Research Plan of the Spanish Ministry of Science and Education) focused in sparids (*Sparus aurata*, *Diplodus sargus* and *Pagrus pagrus*).

- Inert feeds for larval rearing of marine fish: optimization of content in peptids, amino acids and phospholipids (PAI Andalusia Scientific Research Program, Regional government of Andalusia, Spain) focused in *Sparus aurata* and *Solea senegalensis*.
- AQUAGENOMICS - Improvement of aquaculture production by the use of biotechnological tools (Program Consolider-Ingenio 2010, a multi-teams National Research Program funded by the Spanish Ministry of Science and Education) includes the study of fish genes related to growth, nutrition and larval development.
- FUNDIGEST Improvement of food utilization in early stages of marine fish. Gut functionality and macronutrient utilization assessment. (A national project funded by National Research Plan of the Spanish Ministry of Science and Education) focused in *Sparus aurata*, *Dicentrarchus labrax* and *Solea senegalensis*.
- CODTECH a process oriented approach to intensive production of marine juveniles with main emphasis on cod. A strategic research programme at the Norwegian University of Science and Technology (NTNU), funded by the Norwegian Research Council (project No. 153422/120).
- NFR 179016/S40 (2007-2009) Ontogeny of lipid digestion and effects of feeding pre-digested lipids to Atlantic cod (*Gadus morhua*) larvae.
- NFR 163421/S40 (2004-2007) Optimised nutrition and egg quality in Atlantic cod (*Gadus morhua*) broodstock. Nutreco ARC, Cod culture Norway AS, Havlandet marin yngel AS, Sagafjord seafarms AS, Institute of Marine Research, NIFES. Project leader: Nutreco ARC.
- NFR 164842/S40 (2005-2007) Improving metamorphic success and juvenile quality in Atlantic halibut and white groups through dietary supplementation of iodine. NIFES, Institute of Marine research (IMR), University of Bergen, The National Center of Mariculture, Israel, Carnegie Institution of Washington, USA. Project applicant and leader in 2005.
- PROCOD Progressive modern production of Atlantic cod.
- Improving metamorphic success and juvenile quality in Atlantic halibut and white grouper through dietary supplementation of iodine.

- Control of malformations in the production of Atlantic cod (*Gadus morhua* L.) by optimizing temperature and light conditions.
- Digestive function in Atlantic cod larvae - effects of intensive and extensive rearing systems and correlation with peaks in mortality.
- Influence of water temperature and genetic factors on muscle development in farmed cod larvae: consequences for product quality.
- NEW MARINE FEED RESOURCES The building of a consortium towards exploitation of unutilized marine resources for diets to farmed fish.
- Ontogeny of lipid digestion and effects of feeding pre-digested lipids to atlantic cod (*Gadus morhua*) larvae.
- Production of all-female cod as a means to circumvent problems with early puberty in males: Studies on sex determination and differentiation.
- PROPHYLHATCH - Prophylaxis in large scale intensive hatcheries for cod, *Gadus morhua*, and halibut, *Hippoglossus hippoglossus* L..
- Intelfeed, a project funded by the Norwegian Research Council, which seeks to use nanotechnological encapsulation methods to design better larval diets.
- Production of copepod eggs, a project funded by Innovation Norway and MABIT, which seeks to produce copepod eggs on a commercial scale and to improve cod juvenile quality by feeding copepods at certain stages of the larval phase.
- FATTY ACID REQUIREMENTS OF THE LARVAE OF TWO MARINE FISH SPECIES, *Dentex dentex* AND *Solea senegalensis* UNDER CULTURE. Project ACU-02-006, funded by the Spanish Ministry of Education and Sports, and the National Institute of Agriculture Research (INIA), from 2002 to 2005. The project aimed to investigate the larval nutritional requirements in essential fatty acid (EFA) of common dentex (Sparidae) and Senegal sole (Soleidae), two new species for aquaculture in Spain. The requirements of arachidonic (ARA), eicosapentaenoic (EPA) and docosahexaenoic (DHA) acids were studied by means of live prey enriched with experimental emulsions formulated beforehand using different amounts of EFA.

A final purpose of the project was the use of zein microdiets, although the acceptance by the larvae didn't allow its use. Researcher: A. Estevez.

- Dietary effects of nutrients on the larval and juvenile marine fish quality: establishment of the molecular mechanisms responsible for the development of skeletal malformations and depigmentation problems. Project: AGL2005-02478/ACU (Ministry of Education and Science, Spain). The project studies the effects of vitamins A and D on the expression of genes and nuclear receptors involved in the morphogenesis of skeleton and larval metamorphosis in cylindrical (gilthead sea bream) and flatfish (Senegal sole), and also evaluate their effects on fish quality (survival, growth, skeletal malformations, metamorphosis success, pigmentation problems). Researcher: E. Gisbert.
- RESTOCK, funded by the Directorate for Food, Fisheries and Agri Business through the EU Fisheries Sector Programme. This project focuses on the production of viable cod larvae for restocking in the Baltic.
- ROEIII, research grant from the Danish Ministry of Food, Agriculture and Fisheries concerning research on artificial reproduction in eel.
- Flemish Research Council projects Functional role and characteristics of micro-organisms in the larviculture of aquatic organisms: Artemia as preferential test organism and Probiotic-induced functional responses in aquatic organisms
- Ghent University Research Fund project Development of a gnotobiotic larviculture food chain for the study of host-microbiota interactions
- ASEM Aquaculture platform www.asemaquaculture.org
- MAqFish - European Master of Science in Aquaculture and Fisheries www.maqfish.com
- EATP - European Aquaculture Technology Platform Initiative Area Larviculture and Juvenile Production of Fish and Shellfish www.EATPnet.eu
- MCYT/AGL2003-03558 - Spanish funding agency CICYT (SPARUGENES) Skeletal development, alterations and malformations during larval ontogeny of species with interest for aquaculture. Molecular, cellular and biochemical approaches.

- POCTI/CVT/42098/2002 (FISHDEV): Involvement of Gla proteins (MGP and Osteocalcin) in the processes of mineralization occurring in marine versus fresh water teleosts.
- AQUAMAX, an IP project dealing with "sustainable aquafeeds to maximise the health benefits of farmed fish for consumers" in the FP6
- CONSENSUS, an initiative funded under the FP6 as "a platform for sustainable aquaculture in europe" for developing protocols of durability indicators
- COST Action 925 The importance of prenatal events for postnatal muscle growth in relation to the quality of muscle based foods, aiming to explain the interaction between genetics and environment in prenatal events (myogenesis and satellite cell behaviour) in an attempt to find new and alternative methods to be used in selection for optimising postnatal growth and meat/fish quality

Interactions with these initiatives will be accomplished through exchange of information, meetings whenever considered necessary, invitations to researchers from those initiatives to join LARVANET meetings and Workshops. The possibilities for organizing joint seminars/workshops with such initiatives when considered relevant for LARVANET objectives, will be fully explored.

E.4 Gender balance and involvement of early-stage researchers

This COST Action will respect an appropriate gender balance in all its activities and the Management Committee will place this as a standard item on all its MC agendas. The Action will also be committed to especially involve early-stage researchers. This item will also be placed as a standard item on all MC agendas.

F. TIMETABLE

Objectives	Year - 1												Year - 2											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
WG 1 - Basic knowledge on fish larvae biology																								
Review the current state of knowledge																								
Identify critical success factors of mass supply of quality juveniles																								
Identify gaps in the scientific knowledge																								
Short-term scientific missions within the research network																								
Training schools for young researchers																								
Propose research projects to address gaps in knowledge																								
WG 2 - Quality indicators for larval production																								
Identify biological parameters as predictors of quality																								
Develop matrices predicting phenotype and larval quality																								
Identify further research needs on predictors of phenotype and larval quality																								
Test developed phenotype and larval quality predicting matrices																								
Layout a database of fingerlings quality from different sources in Europe																								
WG 3 - Improved production protocols and hatchery management																								
Interact with WG1 and WG2 in defining important information for industry																								
Synthesize the information arising from WG1 and WG2																								
Validate the developed phenotype and larval quality predicting matrices																								
Propose monitoring systems and protocols with best management practices																								
Discuss strategies and implement dissemination of findings and outcomes																								
Workshops																								
Reports																								

Objectives	Year - 3												Year - 4											
	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
WG 1 - Basic knowledge on fish larvae biology																								
Review the current state of knowledge																								
Identify critical success factors of mass supply of quality juveniles																								
Identify gaps in the scientific knowledge																								
Short-term scientific missions within the research network																								
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Propose monitoring systems and protocols with best management practices																								
Discuss strategies and implement dissemination of findings and outcomes																								
Workshops																								
Reports																								

G. ECONOMIC DIMENSION

The following COST countries have actively participated in the preparation of the Action or otherwise indicated their interest: BE, CZ, DE, DK, ES, FR, GR, HU, IL, IT, NO, PL, PT, RO, SE,

TR, UK. On the basis of national estimates, the economic dimension of the activities to be carried out under the Action has been estimated at EUR 13 million for the total duration of the Action. This estimate is valid under the assumption that all the countries mentioned above but no other countries will participate in the Action. Any departure from this will change the total cost accordingly.

H. DISSEMINATION PLAN

H.1 Who?

The target audiences for the dissemination of the results of the LARVANET COST Action include all stakeholders involved in European aquaculture. These include: The industry as represented by hatchery producers and their client on-growing farmers; Governmental agencies; Universities and other research institutions; Standards Bodies; European level policy makers; Government policy makers; Regional planners and policy makers; and also the general public.

H.2 What?

The LARVANET website will have a central role in the dissemination of the COST Action activities and outcomes. This website will include dedicated areas for:

- 1) Posting of general information on LARVANET for the general public, with information useful to all stakeholders previously mentioned in section H.1;
- 2) A document library including relevant publication and reports, including COST Action public reports and recommendations, of special interest to the industry, Governmental agencies, Universities and other research institutions, Standards Bodies, European level policy makers, Government policy makers, and Regional planners and policy makers;
- 3) Posting of working documents on a password protected area, dedicated to LARVANET participants;
- 4) An internet discussion forum, which is expected to be useful to all stakeholders previously mentioned in section H.1, and in particular to the industry, Universities and other research institutions.

LARVANET will organize workshops, seminars and possibly conferences, in an event strategy to be defined by the MC. It will also participate actively and where the MC finds desirable co-organise conferences and symposia with other European/International initiatives. In this respect the obvious targets are the regular European and World Aquaculture Societies (EAS and WAS) conferences, the LARVI international symposia, and eventual EATP initiatives. The target audience of such dissemination activities will be the industry, Governmental agencies, Universities and other research institutions.

LARVANET will publish reports (see deliverables section D) on its main findings, in particular on important aspects to improve sustainability of the European aquaculture industry. These are expected to be helpful to the industry, Governmental agencies, Universities and other research institutions, Standards Bodies, European level policy makers.

LARVANET will also publish articles in peer-reviewed scientific and technical Journals, with particular emphasis to reviews integrating the current state of knowledge in key areas for larval production, benefiting from the multidisciplinary expertise within the network. The target audience of such publications will be the Universities and other research institutions, but also the industry.

H.3 How?

The dissemination methods described in section H.2 will be implemented under the coordination of the Working Group leaders, and with the supervision of the MC. A thorough review of the dissemination plan will be performed at every MC meeting, in order to guarantee that the LARVANET activities as to maximize the dissemination among the different target groups. It is intended that dissemination will go beyond the time span of the COST Action, and the MC will make efforts to guarantee this. For instance, the website will remain active for at least 5 years after the end of the COST Action.
